SURFACE-WATER RESOURCES

INTRODUCTION

Although ground water represents by far the more abundant source of fresh water on earth, in the past man has gone primarily to the rivers, lakes, and streams to take care of his major needs. It has been estimated that 75 percent of all municipal and irrigation supplies, 90 percent of all industrial supplies, and virtually all of the water to generate hydroelectric power comes from the surface waters of our nation. It is quite evident from this that surface waters represent one of our most valuable water resources, and it is, therefore, imperative that they be developed in the most beneficial manner possible. This objective cannot be accomplished unless the extent and nature of this resource is first adequately determined. In the following pages, surface waters in the Nooksack River basin and certain adjacent small streams are inventoried and analyzed with this purpose in mind.

STREAMFLOW CHARACTERISTICS

Contrary to general belief, streamflow is a variable and continuously changing phenomenon. The variations are a direct result of many complex meteorological, physiographic, and geologic factors within a watershed and can best be shown by means of a streamflow hydrograph. Hydrographs of various streams in the Nooksack River basin are presented in figures 13 through 16 and provide good illustrations of this instability.

The fluctuations depicted by a hydrograph can usually be attributed to three rather distinct types of runoff. These are: direct runoff or water that drains from the land immediately after a storm; sub-surface storm runoff in which water is diverted to the stream before penetrating to the regional water table; and ground-water runoff which is a constant contributor as long as the water table slopes down toward the stream and remains in contact with its bed. Although ground-water runoff is usually more continuous throughout a year, the major portion of annual runoff produced by most streams is derived from direct runoff of rainfall and snowmelt.

Flow from direct runoff causes the sharp, abrupt flood peaks on a hydrograph. As storm or snowmelt waters reach a stream, the discharge past a gaging station increases rapidly until a maximum is reached. The flow then drops off and recedes at a progressively slower rate until all direct runoff has been drained from the land. At this time ground water and subsurface storm runoff are the only contributors, and a distinct decrease is noticed in the recession rate. After sub-surface storm runoff subsides, the rate of recession is again reduced and ground water becomes the sole contributor. In general, this process is repeated after every storm, but if natural or artificial storage exists in a basin, the individual contributors may become obscure and the shape of a hydrograph may change considerably as varying quantities of water are alternately accumulated and released throughout a year.

Provided no rain occurs and there are no tributary springs in a basin, streamflow will cease when the water table recedes below the channel bed. Streams that exhibit this characteristic are fairly common in the Nooksack River area and are described as being intermittent. Most of the streams are perennial and flow through the year, while a few in high mountain areas have no baseflow at all and carry surface runoff only. These latter "ephemeral" streams flow only when there is sufficient precipitation or snowmelt to produce runoff.

In addition to the individual fluctuations produced by storms, all three of the above stream types are subject to pronounced seasonal, annual, and long-term variations. Figures 23, 27, 31, 35, 39, 43, and 47 illustrate by means of bar graphs the monthly range in flows that have occurred in several streams in the report area. For example, the graph of the South Fork near Wickersham shows monthly runoff for December as small as 30,740 acre-feet (1952) and as large as 135,300 acre-feet (1934), which is a ratio of maximum to minimum of about 4 to 1. The ratio of maximum to minimum monthly runoff for August for this same record is about 6 to 1. These large differences are not unusual for most streams in this area and other similar comparisons would probably show even greater variations. Another type of stream variation with respect to time may be seen in figure 20, which shows by graphic representation the annual discharge for the South Fork of the Nooksack River over its entire 26-year period of record. Here it is found that the annual runoff varies from 67 percent of the average in 1944 to 126 percent in 1950. As brought out in the chapter on climate, there are indications that precipitation and streamflow vary in cycles over long periods of time. This type of variation along with annual variations, as they apply to the Nooksack area, will be discussed further in the section on streamflow analysis.

Despite the many unpredictable fluctuations in discharge, each stream will ordinarily exhibit its own consistent flow pattern from one year to the next. These patterns or trends for the most part are controlled by seasonal variations in precipitation and storage characteristics within the watershed. On some watersheds almost all precipitation runs off immediately after a storm, while on others it may be stored for months and even years in the form of snow and perennial ice. Storage in marshes, lakes, and reservoirs also influences the flow and provides regulation in many areas.

In the Nooksack River region there are three rather distinct regimes of streamflow caused by various combinations of the above factors in conjunction with other differences in environments. For example, streams which head at the glaciers of Mt. Baker and adjacent peaks have a characteristic high-water period early each summer, a well-sustained flow during late summer and early fall, and a low-water period during winter. The high-water period in spring and early summer represents water coming out of storage in the form of snowmelt from large packs accumulated during winter months. The sustained late summer flow is maintained for the most part by melt water from glaciers and high snow fields, while the low period during winter is the result of freezing temperatures which prevent accumulating snows from melting and running off. This runoff pattern is well expressed by the bar graph showing monthly

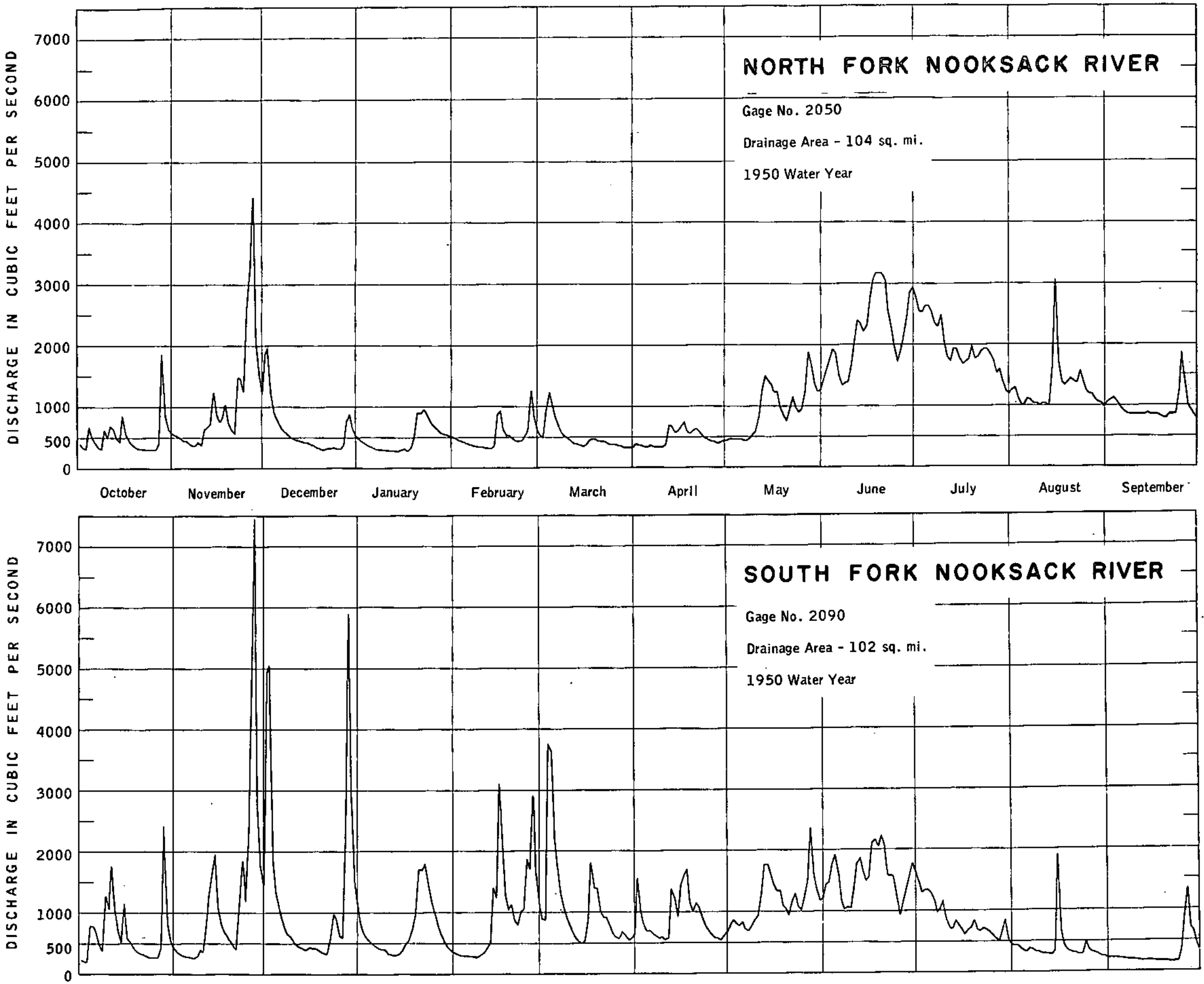


Figure 13. Streamflow Hydrographs of North Fork and South Fork Nooksack River.

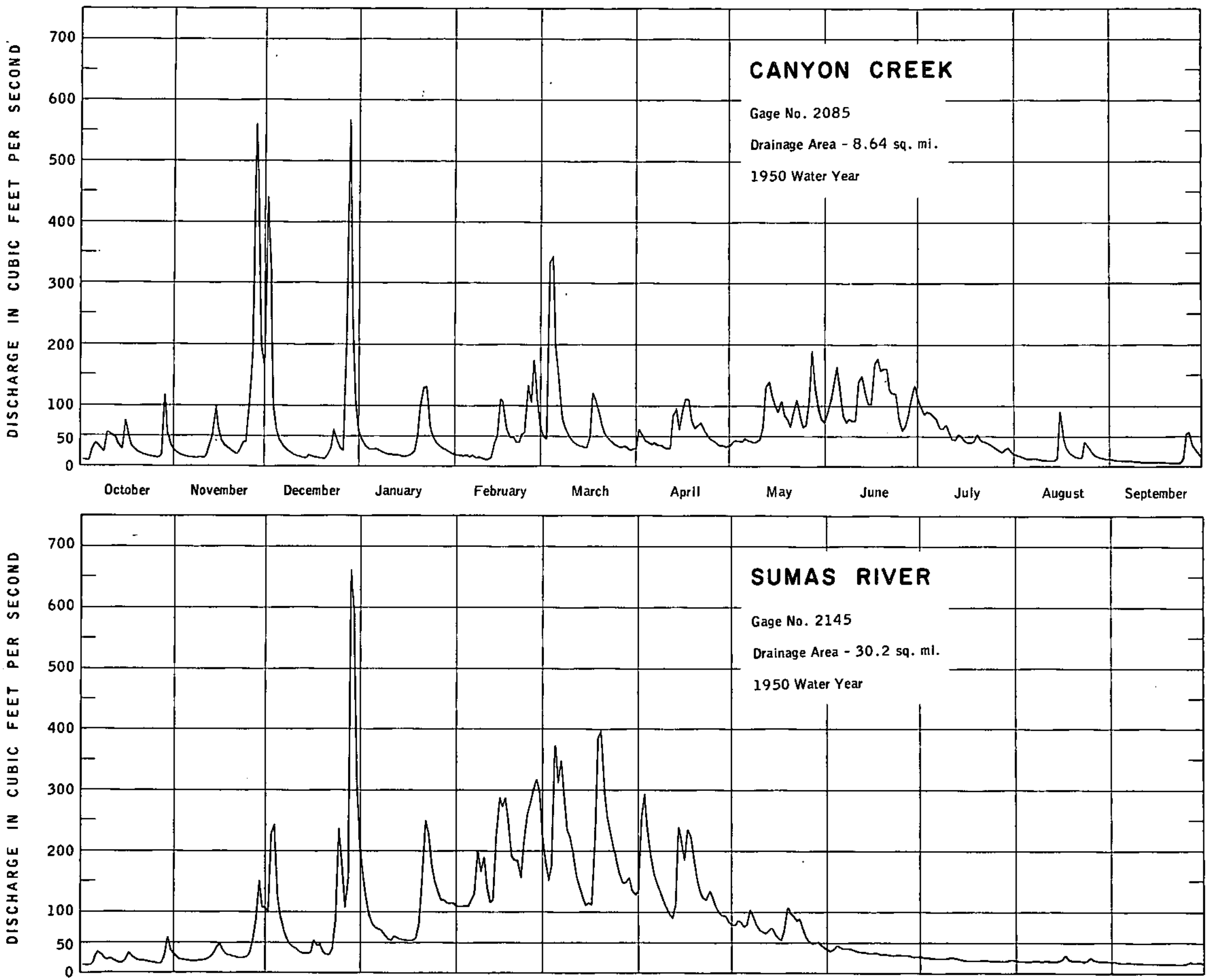


Figure 14. Streamflow Hydrographs of Canyon Creek and Sumas River.

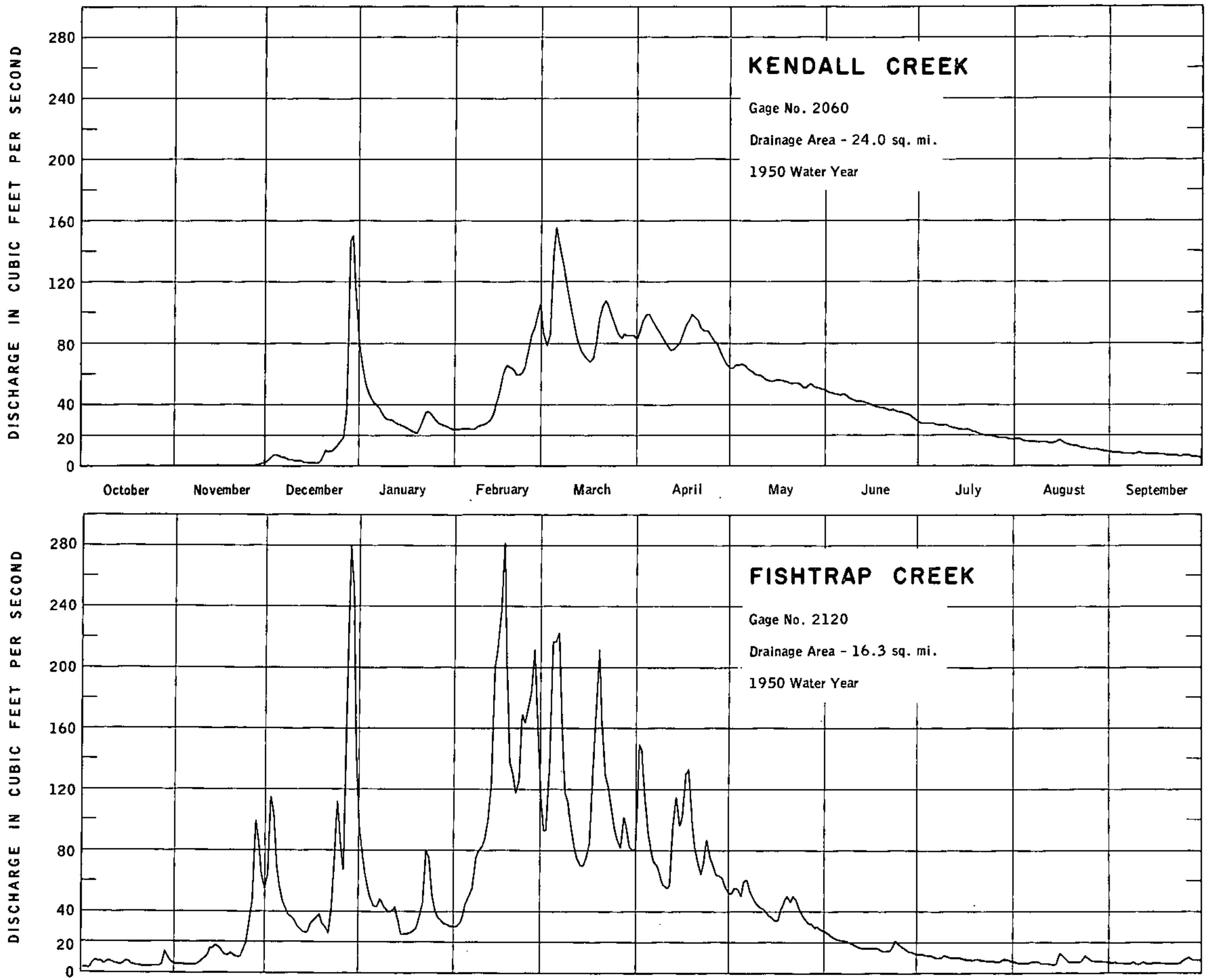
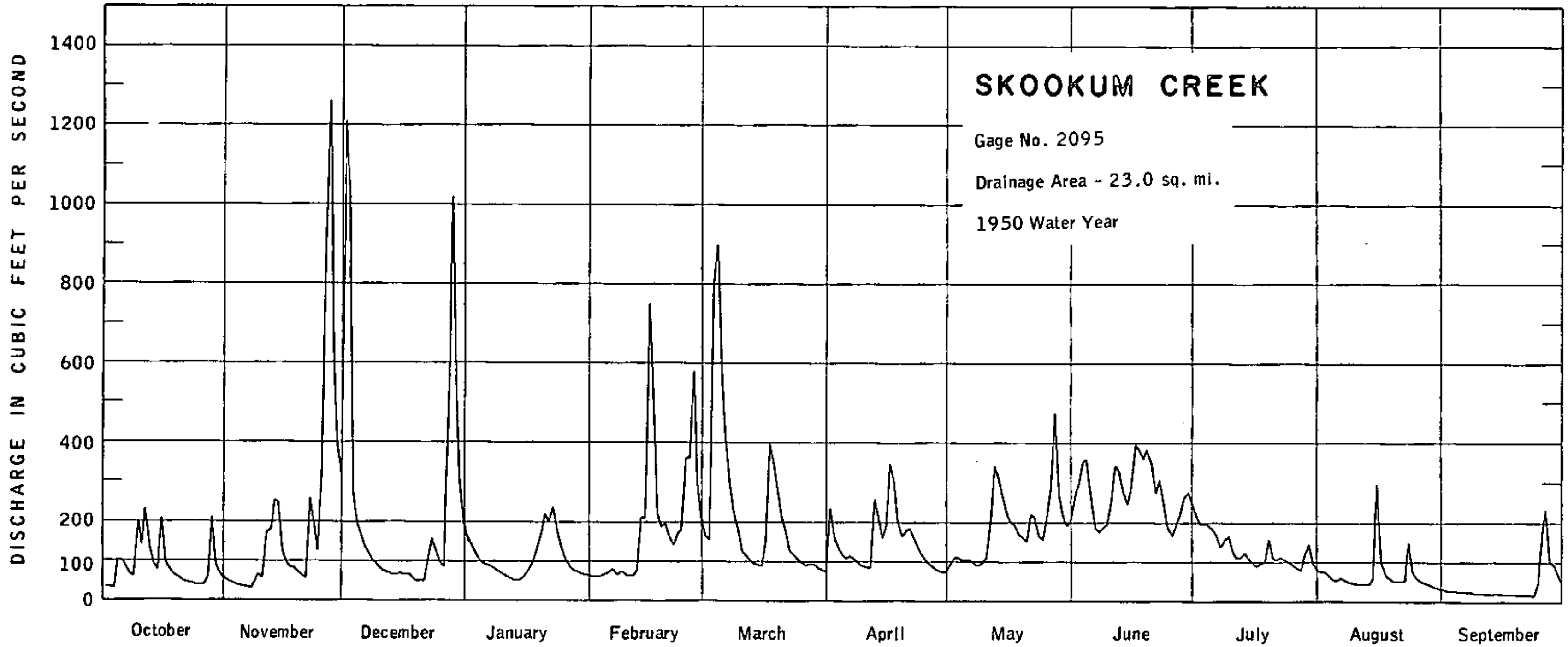


Figure 15. Streamflow Hydrographs of Kendall and Fishtrap Creeks.



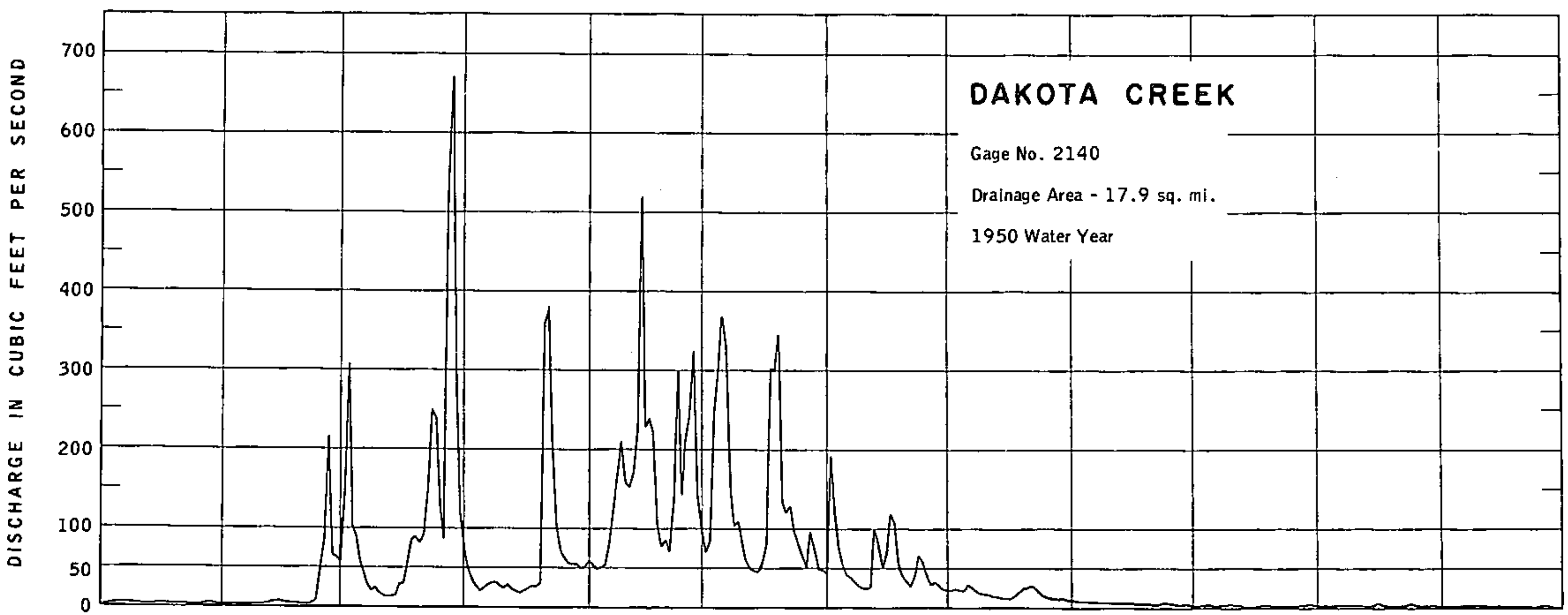


Figure 16. Streamflow Hydrographs of Skookum and Dakota Creeks.

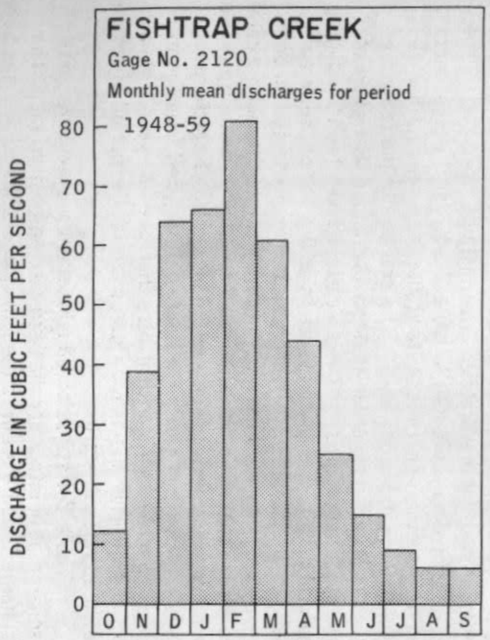


Figure 17.

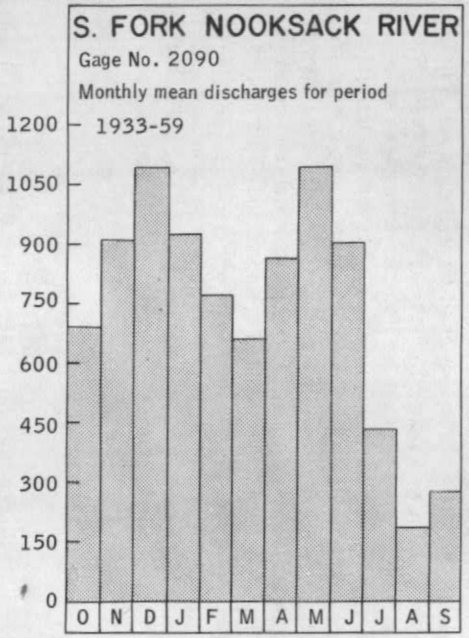


Figure 18.

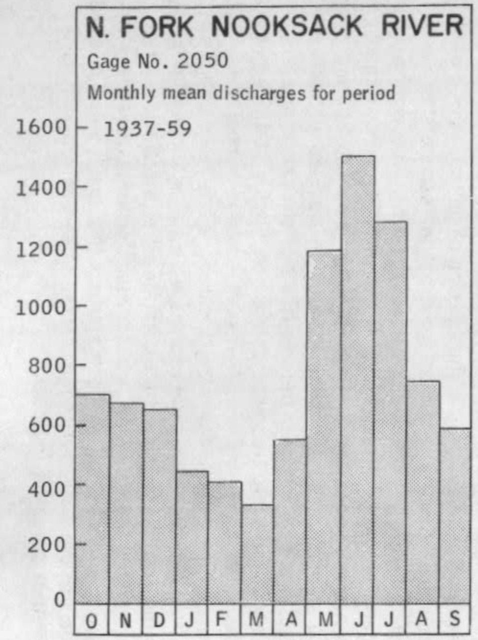


Figure 19.

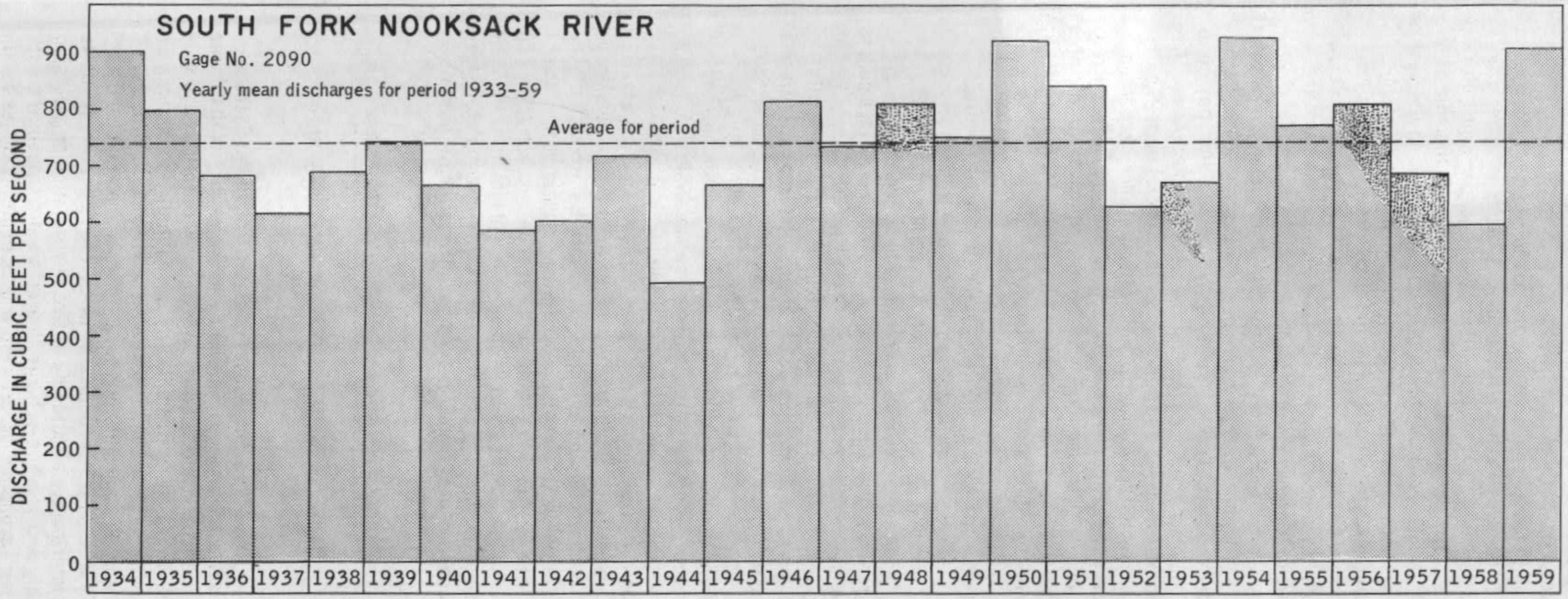


Figure 20.

mean discharges of the North Fork of the Nooksack River below Cascade Creek (fig. 19).

In the second category are streams that originate in mountainous areas where winter precipitation at higher altitudes is largely in the form of snow, and at lower altitudes is rain. In this environment, a large portion of the annual runoff occurs during winter, but is followed later in the year by a second high-water period derived from melting of accumulated winter snows. The low-water period occurs late in summer and early fall because these watersheds lie below the elevation necessary to sustain perennial snow and ice. An illustration of this type of streamflow is shown in figure 18 by the South Fork of the Nooksack River near Wickersham.

The third category includes streams whose basins lie largely at low altitudes. Some winter precipitation may be in the form of snow, but in general the snow is short-lived. Annual runoff of these streams follows the general pattern of annual precipitation with the period of maximum discharges occurring from October to February and then gradually decreasing along with the precipitation trend to minimum flows during August and September. Streams which follow this typical regimen are illustrated by Fishtrap Creek (fig. 17).

Certain generalizations about the characteristics of a watershed can also be made by again studying streamflow hydrographs. If flow increases of various streams are analyzed during a period when runoff occurs immediately after a storm and is not stored or appreciably detained in any way from reaching the stream channel, it will be noted that peaks on the hydrographs vary between those that are extremely sharp and short in duration and those that are rather indistinct and flat. The sharp peaks are characteristic of streams in steep, rugged topography usually underlain by impervious, consolidated rocks, while hydrographs that show only low extended rises are associated with mature topography and permeable, unconsolidated sub-surface materials. A good illustration of the former condition can be seen from the hydrograph of Skookum Creek near Wickersham (fig. 16. This stream displays extremely variable flows and its watershed is characterized by rugged and rocky terrain with a relatively thin soil mantle. A striking example of the latter condition is shown in the Kendall Creek hydrograph (fig. 15). Although this basin contains several low mountains, the major portion adjacent to the main stream is almost completely level and consists of permeable, unconsolidated glacial deposits.

BASIC STREAMFLOW DATA

(By E. G. Bailey, U. S. Geological Survey)

Basic streamflow data consist of records of streamflow collected at gaging stations and the results of discharge measurements made at other sites. The streamflow data collected at gaging stations usually are published as records of daily discharge in cubic feet per second (cfs) ; as monthly discharge in cubic feet per second and in acre-feet; and as yearly discharge. In addition, where the flow at a station is not significantly affected by upstream regulation or diversion, monthly and yearly discharge figures are also given in cubic feet per second per square mile and as depth in inches for the drainage basin. Discharge measurements made at sites other than at gaging stations are made by current meter or by indirect methods that utilize the slope indicated by high-water marks and data on the size, shape, and roughness of channels or of bridge and culvert openings.

Streamflow data have been collected at 23 gaging stations in or adjacent to the Nooksack River basin; many of these stations have only a short period of record. Some of these short-term records were from reconnaissance stations operated early in the development of the area to determine the general pattern of streamflow. Other short-term records, in more recent years, are from gaging stations operated during low-flow summer seasons in conjunction with a series of measurements made to inventory the low flows of streams in the area. A few of the short-term records are from gaging stations that were moved to other sites after a short period of operation showed them to be unfavorably located. Five years or more of continuous daily discharge records were collected at 8 of the gaging stations. Streamflow data for all of the stations are summarized in this report. In addition, continuous records of daily discharge for 7 of these stations that are 5 years or more in length are analyzed and presented in several ways as described in the following pages.

BAR CHART OF GAGING STATION RECORDS

All gaging stations that have been operated in the report area are listed in the bar chart located on page 41, together with the years during which each station was operated. The stations in each basin are listed in downstream order. Thus, proceeding in a downstream direction along the main stem, all stations on a tributary that enter above a main-stem station are listed before that station. If a tributary enters between two main-stem stations, it is listed between them. Tributary streams are indicated by indention. This downstream order and system of indention show which gaging stations are on tributaries between any two stations on a main stem. Each station has been assigned a number that can be used to locate the station on the surface-water maps (pls. 4 and 5).

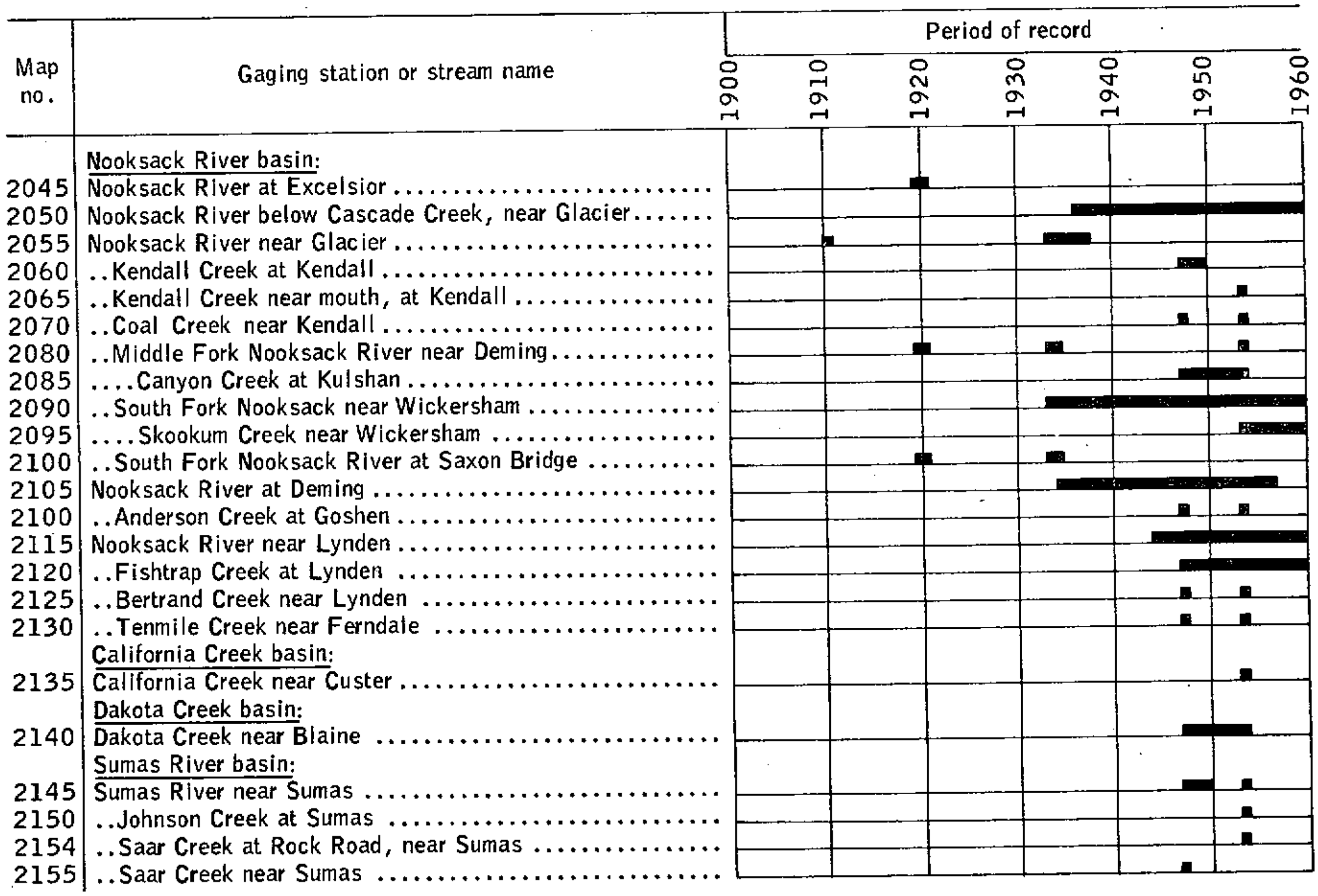
SUMMARY OF DATA

Basic data that have been collected at gaging stations and at miscellaneous discharge measurement points in the report area are summarized in tables 2 and 3. More detailed data for each station will generally be found in water-supply papers published by the U. S. Geological Survey or in bulletins published by the State of Washington.

The data presented in table 2 are, for the most part, self-explanatory; only those items that may need further explanation are described here. The stations in the table are listed in downstream order as described under "Bar chart of gaging station records." The elevation shown for each gaging station is the approximate elevation of the bed of the stream above mean sea level. Discharge data are presented on both annual and seasonal bases. The ratios relate the mean annual and mean seasonal discharges for the period of record to those for a long-term period (see section on "Ratio of discharge," p. 41). Maximum discharge figures are omitted from the extremes columns for records of less than one full year. Maximum and minimum discharge figures are for the period of record indicated at each station.

Table 3 lists selected miscellaneous measurements of discharge at points other than stream-gaging stations. The discharge listed therein is the minimum discharge that has been measured at each site; it is not necessarily the minimum discharge that has occurred in the past or that can be expected to occur in the future. In almost every case, however, each discharge listed approximates the minimum flow at that point during the low-water season in which the measurement was made. When evaluated such measurements are helpful in

Figure 21. BAR CHART OF GAGING STATION RECORDS.



appraising the overall water supply and in determining the potential low flow at the places where they were made. At some sites, several measurements have been made in addition to those reported herein; the results of these additional measurements are contained in the U. S. Geological Survey water-supply papers (WSP) listed in the column headed "Publication."

RATIO OF DISCHARGE

The natural flow of streams varies from day to day and from year to year. Therefore, to evaluate the potential runoff of a stream, the relationship of the known discharge of record to that for a long-term period must be determined. The procedure used to estimate this relationship was to compute the ratio of each annual mean discharge of a long-term record to the average of all the annual mean discharges at the same station. In addition, ratios were computed to show the relation of the seasonal July to September mean discharge of each year to the average of all the seasonal discharges.

The index station used for computing these ratios is South Fork Nooksack River near Wickersham. This station has the longest period of continuous record (water years 1934 to 1959) of any station in the report area. With the possible exception of the glacier-fed streams, the annual and seasonal (July to September) runoff patterns for most streams in the area compare favorably with those for South Fork Nooksack River. Glacier streams usually have runoff characteristics which preclude the application of ratios without adjustment for other factors.

Tables included herein show ratios of both annual discharge and seasonal discharge each year to the average for 1934-59. In each table the ratio figure of 1.00 represents a discharge equal to the average for the base period, 1934-59. For example, the discharge ratio of 1.26 for the water year 1950 means that the discharge for 1950 was 126 percent of the average discharge for the 26-year base period; similarly, the average ratio of 0.88 for the 4-year period 1940-43 means that the average annual discharge for that period was 88 percent of the average discharge for the base period. Ratio figures for years 1910 to 1933 were estimated on the basis of long-term records of streams outside the Nooksack River basin.

The basic streamflow data from 7 of the stations listed in table 2 are summarized and presented in this section to demonstrate the streamflow characteristics and to provide a basis for further study. These gaging stations, each of which has 5 years or more of continuous record, are listed below.

Map no.	Gaging station
2050	Nooksack River below Cascade Creek, near Glacier
2085	Canyon Creek near Kulshan
2090	South Fork Nooksack River near Wickersham
2095	Skookum Creek near Wickersham
2115	Nooksack River near Lynden
2120	Fishtrap Creek at Lynden
2140	Dakota Creek near Blaine

Table 2. Summary of Gaging Station Streamflow Records.

Sta. No.	Name	Location	Drain. Area (sq mi)	Elev. (ft above m.s.l.)	Period of Record	Annual discharge (water year ending			
						Maximum		Minimum	
						Acre-feet	Year	Acre-feet	Year
	NOOKSACK RIVER BASIN								
2045	Nooksack River at Excelsior	Sec.31, T.40N., R.8E., ½ mile downstream from Wells Creek.	95.7	1,320	1920-21	-	-	-	-
2050	Nooksack River below Cascade Creek, near Glacier	NW¼ sec.1, T.39N., R.7E., ¼ mile downstream from Cascade Creek.	104	1,245	1937-	689,200	1950	392,400	1944
2055	Nooksack River near Glacier	NE¼ sec.2, T.39N., R.6E., 600 ft downstream from Canyon Creek.	192	720	1911, 1933-38	1,042,000	1934	709,000	1937
2060	Kendall Creek at Kendall	NW¼ sec.34, T.40N., R.5E., 1½ miles upstream from mouth.	24.0	430	1948-50	25,610	1950	15,720	1949
2065	Kendall Creek near mouth, at Kendall	NE¼ sec.3, T.39N., R.5E., 3/4 mile upstream from mouth.	29.2	410	1954	-	-	-	-
2070	Coal Creek near Kendall	NW¼NW¼ sec.10, T.39N., R.5E., ¼ mile upstream from mouth.	4.7	400	1948, 1954	-	-	-	-
2080	Middle Fork Nooksack River near Deming	NW¼ sec.13, T.38N., R.5E., ¼ mile downstream from Heislers Creek.	72.8	590	1920-21, 1934-35, 1954	481,000	1921	355,100	1935
2085	Canyon Creek at Kulshan	SE¼SE¼ sec.27, T.39N., R.5E., ¼ mile upstream from mouth.	8.64	350	1948-54	45,770	1951	28,180	1952
2090	South Fork Nooksack River near Wickersham	SW¼ sec.26, T.37N., R.5E., 3/4 mile upstream from Skookum Creek.	102	385	1933-	675,300	1954	353,900	1944
2095	Skookum Creek near Wickersham	NE¼ sec.27, T.37N., R.5E., 500 ft upstream from mouth.	23.0	400	1948-	118,800	1954	75,910	1958
2100	South Fork Nooksack River at Saxon Bridge	SE¼ sec.21, T.37N., R.5E., 1½ miles downstream from Skookum Creek.	129	350	1920-21, 1933-34	-	-	-	-
2105	Nooksack River at Deming	Sec. 6, T.38N., R.5E., 800 ft downstream from South Fork.	582	204	1935-57	3,144,000	1954	1,617,000	1944
2110	Anderson Creek at Goshen	E½ sec.19, T.39N., R.4E., ½ mile upstream from mouth.	12.9	145	1948, 1954	-	-	-	-
2115	Nooksack River near Lynden	NE¼NE¼ sec.36, T.40N., R.2E., 1½ miles upstream from Fishtrap Creek.	646	24	1944-	3,308,600	1959	2,099,860	1958
2120	Fishtrap Creek at Lynden	On north line sec.16, T.40N., R.3E., 1 mile north of Lynden.	16.3	110	1948-	37,740	1951	16,110	1958
2125	Bertrand Creek near Lynden	SE¼ sec.27, T.40N., R.2E., 3/4 mile upstream from mouth.	38.5	35	1948, 1954	-	-	-	-
2130	Tenmile Creek near Ferndale	NE¼SW¼ sec.22, T.39N., R.2E., 100 ft downstream from county bridge.	25.8	20	1948, 1954	-	-	-	-
	COASTAL AREA BASINS								
	California Creek Basin								
2135	California Creek near Custer	SE¼SE¼ sec.27, T.40N., R.1E., at Porter Road crossing.	11.0	15	1954	-	-	-	-

September 30)		Seasonal discharge (July to September)						Extremes of discharge			
Mean	Annual ratio	Maximum		Minimum		Mean	Season ratio	Maximum (cfs)	Date	Minimum (cfs)	Date
Acre-feet		Acre-feet	Year	Acre-feet	Year	Acre-feet					
576,000 (1 year)	1.26	-	-	-	-	177,900 (1 season)	1.35	4,650	Oct. 4, 1920	186	Feb. 5-9, 1921
545,900 (22 years)	1.00	253,920	1950	112,210	1958	159,000 (22 seasons)	1.03	10,300	Nov. 26, 1949	73	Feb. 16, 1949
830,900 (5 years)	1.00	315,200	1911	164,620	1936	212,520 (6 seasons)	0.79	9,400	Oct. 28, 1937	130	Oct. 17, 1934
20,660 (2 years)	1.14	2,750	1950	707	1949	1,440 (3 seasons)	1.48	162	Dec. 29, 1949	0	Sept. 10 to Nov. 26, 1949
-	-	-	-	-	-	3,340 (1 season)	2.01	-	-	5.7	Oct. 16, 18, 31, 1954
-	-	1,700	1954	1,280	1948	1,490 (2 seasons)	1.64	-	-	0.7	Aug. 13, 1948
418,000 (2 years)	1.17	109,420	1954	58,690	1935	82,700 (4 seasons)	1.28	-	-	127	Apr. 9, 1935
37,890 (5 years)	1.04	7,130	1954	841	1951	4,240 (7 seasons)	1.27	-	-	1.0	Sept. 15-24, 1951
529,200 (26 years)	1.00	109,590	1954	18,290	1940	54,450 (26 seasons)	1.00	19,300	Nov. 3, 1955	66	Oct. 9, 1940, Sept. 11-13, 1944
97,740 (11 years)	1.06	19,220	1954	6,050	1951	12,970 (12 seasons)	1.23	3,050	Nov. 27 or Dec. 1, 1949	17	Feb. 9, 10, 1949
743,300 (1 year)	1.23	147,000	1933	54,610	1934	104,900 (3 seasons)	1.43	13,100	Feb. 11, 1921	111	Sept. 4, 1934
2,350,000 (22 years)	0.98	670,400	1954	254,160	1940	411,800 (22 seasons)	1.00	43,200	Feb. 10, 1951	502	Nov. 29, 1952
-	-	616	1948	551	1954	584 (2 seasons)	1.64	-	-	0.3	Aug. 1-3, 9-15, 1954
2,698,000 (15 years)	1.05	679,800	1954	321,260	1951	472,580 (15 seasons)	1.16	46,200	Feb. 10, 1951	595	Nov. 30, 1952
25,560 (11 years)	1.06	1,690	1959	589	1958	1,240 (12 seasons)	1.23	550	Feb. 11, 1951	0.4	Sept. 10, 1949
-	-	2,970	1954	2,820	1948	2,900 (2 seasons)	1.64	-	-	7.6	Aug. 12, 1954
-	-	1,530	1948	1,480	1954	1,500 (2 seasons)	1.64	-	-	3.2	Aug. 2, 1954
-	-	-	-	-	-	264 (1 season)	2.01	-	-	0.8	Aug. 10-15, 1954

Table 2. Summary of Gaging Station Streamflow Records. (Continued)

Sta. No.	Name	Location	Drain Area (sq mi)	Elev. (ft above m.s.l.)	Period of Record	Annual discharge (water year ending			
						Maximum		Minimum	
						Acre-feet	Year	Acre-feet	Year
	Dakota Creek Basin								
2140	Dakota Creek near Blaine	NW¼SW¼ sec.14, T.40N., R.1E., 50 ft above county bridge, 3½ miles upstream from mouth.	17.9	20	1948-54	35,900	1950	13,240	1952
	SUMAS RIVER BASIN								
2145	Sumas River near Sumas	NE¼ sec.11, T.40N., R.4E., at road crossing, 1½ miles south of Sumas.	30.2	40	1948-50, 1954	61,020	1950	44,400	1949
2150	Johnson Creek at Sumas	SW¼ sec.35, T.41N., R.4E., 1 mile upstream from mouth.	20.4	35	1954	-	-	-	-
2154	Saar Creek at Rock Road, near Sumas	On north line sec.6, T.40N., R.5E., 3/4 mile upstream from international boundary.	9.43	30	1954	-	-	-	-
2155	Saar Creek near Sumas	E½ sec.31, T.41N., R.5E., ¼ mile upstream from international boundary.	10.0	30	1948	-	-	-	-

September 30)		Seasonal discharge (July to September)						Extremes of discharge			
Mean	Annual ratio	Maximum		Minimum		Mean	Season ratio	Maximum (cfs)	Date	Minimum (cfs)	Date
Acre-feet		Acre-feet	Year	Acre-feet	Year	Acre-feet					
23,000 (5 years)	1.04	630	1948	279	1951	459 (7 seasons)	1.27	669	Dec. 27, 1949	0.1	Aug. 11, 1950, Sept. 22, 1952
52,710 (2 years)	1.14	4,910	1954	3,630	1950	4,220 (4 seasons)	1.62	800	Dec. 28, 1949	13.5	Sept. 27 to Oct. 4, 1949
-	-	-	-	-	-	3,740 (1 season)	2.01	-	-	17	Oct. 3-7, 1954
-	-	-	-	-	-	818 (1 season)	2.01	-	-	0.6	Aug. 12, 1954
-	-	-	-	-	-	864 (1 season)	1.27	-	-	0.9	Aug. 13, 1948

Table 3. Miscellaneous Low Flow Discharge Measurements.

Map No.	Stream	Location	Drain. area (sq mi)	Publication (WSP)	Minimum discharge measured	
					Cfs	Date
	NOOKSACK RIVER DRAINAGE BASIN					
NS1	Nooksack River	Sec.32, T.40N., R.8E., at Puget Sound Power and Light Co. gaging station, 1½ miles above Wells Creek.	67.6	767	612	Sept. 13, 1934
NS2	Lookout Creek	SE¼ sec.35, T.40N., R.7E., at Mt. Baker Highway crossing, 4 miles east of Glacier.	1.06	1122, 1346	0.52	Sept. 29, 1954
NS3	Unnamed stream (tributary to Nooksack River)	NW¼ sec.2, T.39N., R.7E., at Mt. Baker Highway crossing, 3½ miles east of Glacier.	0.20	1122, 1346	0.22	Sept. 22, 1948
NS4	Deer Horn Creek	SW¼ sec.34, T.40N., R.7E., at Mt. Baker Highway crossing, 2½ miles east of Glacier.	0.72	1122, 1346	0.34	Sept. 8, 1954
NS5	Coal Creek	SW¼ sec.33, T.40N., R.7E., at Mt. Baker Highway crossing, 2 miles east of Glacier.	0.73	1122, 1346	0.10	Sept. 8, 1954
NS6	Glacier Creek	NE¼ sec.7, T.39N., R.7E., at Mt. Baker Highway crossing, at Glacier.	32.1	512, 1346	111	Sept. 29, 1954
NS7	Gallop Creek	NE¼ sec.7, T.39N., R.7E., at Mt. Baker Highway crossing at Glacier.	2.11	1122, 1346	5.26	Sept. 29, 1954
NS8	Cornell Creek	SE¼ sec.1, T.39N., R.6E., at Mt. Baker Highway crossing, 1 mile west of Glacier.	5.28	1122, 1346	1.54	Sept. 29, 1954
NS9	Canyon Creek	NW¼ sec.35, T.40N., R.6E., 300 ft above mouth and 2 miles northwest of Glacier.	30.9	1122, 1346	87.9	Sept. 29, 1954
NS10	Unnamed stream (tributary to Nooksack River)	NE¼ sec.34, T.40N., R6E., at Mt. Baker Highway crossing, 3 miles northwest of Glacier.	0.70	1122, 1346	0.04	Sept. 9, 1954
NS11	Unnamed stream (tributary to Nooksack River)	SW¼ sec.27, T.40N., R.6E., at Mt. Baker Highway crossing, 4 miles northwest of Glacier.	0.28	1122, 1346	0.48	Sept. 29, 1954
NS12	Unnamed stream (tributary to Nooksack River)	SW¼ sec.27, T.40N., R.6E., at Mt. Baker Highway crossing, 4½ miles northwest of Glacier.	0.25	1122	0.10	Sept. 22, 1948
NS13	Boulder Creek	NW¼SE¼ sec.28, T.40N., R.6E., at Mt. Baker Highway crossing, 2 miles east of Maple Falls.	7.96	1122, 1346	15.8	Sept. 9, 1948
NS14	Maple Creek	South line sec.30, T.40N., R.6E., at Mt. Baker Highway crossing at Maple Falls.	10.1	1122, 1152, 1346	0.79	Aug. 17, 1948
NS15	Unnamed stream (tributary to Kendall Creek)	NW¼ sec.36, T.40N., R.5E., at Mt. Baker Highway crossing, 1¼ miles east of Kendall.	1.27	1122	2.86	Sept. 22, 1948
2065	Kendall Creek	NE¼ sec.3, T.39N., R.5E., at former gaging station, ½ mile above mouth, and 3/4 mile south of Kendall.	29.2	1346, 1566	3.23	Aug. 21, 1958
NS16	Racehorse Creek	N½ sec.10, T.39N., R.5E., at logging road crossing 3½ miles norh of Kulshan.	11.0	1346	8	Sept. 14, 1954
2070	Coal Creek	NW¼NW¼ sec.10, T.39N., R.5E., at former gaging station, ¼ mile above mouth.	4.57	1122, 1346, 1396, 1446, 1566, 1636	0.20	Sept. 8, 1956
NS17	Unnamed stream (tributary to Nooksack River)	NE¼ sec.9, T.39N., R.5E., at Mt. Baker Highway crossing, 2½ miles south of Kendall.	0.23	1122	0	Summer 1948
NS18	Unnamed stream (tributary to Nooksack River)	NW¼ sec.27, T.39N., R.5E., at mouth, 1 mile north of Kulshan.	3.09	1396	53.4	Oct. 6, 1954

Table 3. Miscellaneous Low Flow Discharge Measurements. (Continued)

Map No.	Stream	Location	Drain. area (sq mi)	Publication (WSP)	Minimum discharge measured	
					Cfs	Date
	NOOKSACK RIVER DRAINAGE BASIN (continued)					
NS19	Bells Creek	SE¼ sec.21, T.39N., R.5E., at Mt. Baker Highway crossing, 1½ miles northwest of Kulshan.	4.15	1122, 1152, 1346, 1396, 1446, 1566, 1636	0.20	Sept. 8, 1956
NS20	Nooksack River	West line sec.27, T.39N., R.5E., at highway bridge, ½ mile above Middle Fork, and 1 mile west of Kulshan.	293	1122, 1346	1640	Sept. 15, 1954
NS21	Middle Fork Nooksack River	SW¼ sec.30, T.38N., R.7E., 1/8 mile above Deming ranger station.	24.5	312	212	Oct. 11, 1910
NS22	Middle Fork Nooksack River	NW¼ sec.21, T.38N., R.6E., 100 ft above Clearwater Creek and 6 miles southeast of Kulshan.	46.4	1396	132	Oct. 6, 1954
NS23	Clearwater Creek	NW¼ sec.21, T.38N., R.6E., at mouth, 6 miles southeast of Kulshan.	21.1	1346, 1396	29.8	Oct. 6, 1954
NS24	Falls Creek	N½ sec.20, T.38N., R.6E., at mouth, 5½ miles southeast of Kulshan.	0.75	1396	0.83	Oct. 6, 1954
NS25	Unnamed stream (tributary to Heislers Creek)	W½ sec.13, T.38N., R.5E., at mouth, 4 miles southeast of Kulshan.	0.45	1396	0.24	Oct. 6, 1954
NS26	Heislers Creek	W½ sec.13, T.38N., R.5E., at mouth, 4 miles southeast of Kulshan.	1.70	1346, 1396	0.69	Oct. 6, 1954
NS27	Porter Creek	SE¼ sec.11, T.38N., R.5E., at road crossing 3 miles southeast of Kulshan.	4.23	1346, 1396, 1636	0.59	Sept. 12, 1959
NS28	Unnamed stream (tributary to Middle Fork Nooksack River)	Center of sec.2, T.38N., R.5E., at Mosquito Lake road crossing, 1 3/4 miles southeast of Kulshan.	0.46	1396	0	Oct. 6, 1954
NS29	Unnamed creek (tributary to Middle Fork Nooksack River)	NW¼ sec.35, T.39N., R.5E., at road crossing 1 mile south of Kulshan.	1.21	1396	2.15	Oct. 6, 1954
NS30	Nooksack River	SE¼ sec.6, T.38N., R.5E., at railroad trestle just above South Fork and 1 mile southeast of Deming.	400	1122, 1346	2200	July 23, 1948
NS31	South Fork Nooksack River	Sec.21, T.36N., R.6E., ¼ mile above Lyman Timber Co. railroad bridge.	65.6	752	135	Sept. 10, 1933
NS32	Cavanaugh Creek	NW¼ sec.1, T.36N., R.5E., at logging road crossing 4½ miles east of Wickersham.	9.68	1346	12.4	Sept. 30, 1954
NS33	Unnamed stream (tributary to South Fork Nooksack River)	SE¼ sec.35, T.37N., R.5E., at logging road crossing 4 miles east of Wickersham.	0.58	1346	0	Sept. 30, 1954
NS34	South Fork Nooksack River	Sec.35, T.37N., R.5E., 1,000 ft above Edfro Creek.	100	752	135	Sept. 13, 1933
NS35	Edfro Creek	NE¼ sec.35, T.37N., R.5E., at logging road crossing 4 miles east of Wickersham.	2.18	1346	1.68	Sept. 30, 1954
NS36	Hutchinson Creek	NW¼ sec.2, T.37N., R.5E., at road crossing, 3 miles east of Acme.	10.8	1122, 1346	7.53	Sept. 8, 1954
NS37	Jones Creek	North line sec.7, T.37N., R.5E., at road crossing at Acme.	2.31	1122, 1346	0.01	Sept. 21, 1948
NS38	Unnamed stream (tributary to South Fork Nooksack River)	West line sec.5, T.37N., R.5E., at road crossing ½ mile north of Acme.	1.04	1122, 1152, 1346	2.14	Sept. 21, 1948

Table 3. Miscellaneous Low Flow Discharge Measurements. (Continued)

Map No.	Stream	Location	Drain. area (sq mi)	Publication (WSP)	Minimum discharge measured	
					Cfs	Date
	NOOKSACK RIVER DRAINAGE BASIN (continued)					
NS39	McCarty Creek	NW¼ sec.6, T.37N., R.5E., at road crossing, 3/4 mile northwest of Acme.	1.64	1122, 1346	0.73	Sept. 10, 1954
NS40	Black Slough	NW¼ sec.17, T.38N., R.5E., at road crossing, ½ mile south of VanZandt.	6.94	1122, 1152, 1346	0	Aug., 20, 1949 Sept. 9, 1954
NS41	Nooksack River	Sec.28, T.39N., R.4E., at Nugent's bridge.	594	312, 792	1600	Feb. 14, 1911
NS42	McCauley Creek	W½ sec.26, T.39N., R.4E., at Mt. Baker Highway crossing, 1 mile northwest of Deming.	3.66	1346, 1396	0.62	Oct. 1, 1954
NS43	Smith Creek	West line sec.22, T.39N., R.4E., at highway crossing, ½ mile southeast of Lawrence.	10.3	1346, 1396	0.37	Aug. 19, 1948
NS44	Anderson Creek	SE¼ sec.6, T.38N., R.4E., at Mt. Baker Highway crossing, 3 miles south of Goshen.	7.25	1122, 1152, 1346, 1396 1446, 1636	0.10	Aug. 8, 1956
2110	Anderson Creek	NE¼ sec.19, T.39N., R.4E., at former gaging station at Goshen, ½ mile above mouth.	12.9	1122, 1152, 1346, 1396, 1446, 1636	0.19	Sept. 7, 1956 Aug. 10, 1959
NS45	Kamm Ditch	NW¼ sec.14, T.40N., R.3E., at Lynden-Sumas Road crossing, 2½ miles northeast of Lynden.	0.66	1346, 1396	0.70	Oct. 1, 1954
NS46	Kamm Ditch	Center S½ sec.15, T.40N., R.3E., at road crossing 80 ft north of Milwaukee Railroad tracks, 1½ miles east of Lynden.	2.73	1346, 1396	2.92	Oct. 1, 1954
NS47	Mormon Ditch	N½ sec.22, T.40N., R.3E., at Norwood Road crossing, 1½ miles east of Lynden.	2.30	1346	0.21	Sept. 14, 1954
NS48	Stickney Slough	SE¼ sec.20, T.40N., R.3E., at Lynden, 500 ft above mouth.	7.88	1346	5.81	Sept. 14, 1954
NS49	Scott Ditch	SE¼ sec.29, T.40N., R.3E., at Hannegan Road crossing, 1 mile south of Lynden.	8.03	1122, 1152, 1346, 1396	3.41	Oct. 1, 1954
NS50	Unnamed stream (tributary to Nooksack River)	Center E½ sec.36, T.40N., R.2E., 500 ft west of Meridian Road and 2¼ miles southwest of Lynden.	0.86	1346	0.24	Sept. 14, 1954
NS51	East Branch Double Ditch Creek	NE¼ sec.31, T.41N., R.3E., at international boundary, 4 miles north of Lynden.	*	962, 982, 1122, 1152, 1346, 1396	1.42	Oct. 12, 1942
NS52	East Branch Double Ditch Creek	South line sec.7, T.40N., R.3E., at Blaine-Sumas Road crossing, 1 mile northwest of Lynden.	*	1122, 1346, 1396	2.52	Oct. 1, 1954
NS53	West Branch Double Ditch Creek	NW¼ sec.31, T.41N., R.3E., at international boundary, 4 miles north of Lynden.	*	962, 982, 1122, 1152, 1346, 1396	3.05	Aug. 23, 1955
NS54	West Branch Double Ditch Creek	South line sec.7, T.40N., R.3E., at Blaine-Sumas Road crossing, 1 mile northwest of Lynden.	*	1122, 1346, 1396	2.22	Sept. 10, 1954
NS55	Double Ditch Creek	NE¼ sec.19, T.40N., R.3E., just below confluence of branches, at Lynden.	4.11	962, 982	3.52	Oct. 12, 1942

*Drainage areas are indeterminant

Table 3. Miscellaneous Low Flow Discharge Measurements. (Continued)

Map No.	Stream	Location	Drain. area (sq mi)	Publication (WSP)	Minimum discharge measured	
					Cfs	Date
	NOOKSACK RIVER DRAINAGE BASIN (continued)					
NS56	Fishtrap Creek	NE¼ sec.25, T.40N., R.2E., at highway crossing, 1 mile southwest of Lynden.	28.5	962, 982, 1122, 1152, 1346, 1396, 1636	4.85	Aug. 18, 1958
NS57	Fishtrap Creek	SW¼ sec.35, T.40N., R.2E., at mouth.	30.6	1346	15.1	Sept. 11, 1954
NS58	Bertrand Creek	SE¼ sec.11, T.40N., R.2E., at Blaine-Sumas Road crossing, 2½ miles northwest of Lynden.	26.9	1122, 1346, 1396, 1636	2.65	Aug. 8, 1956
NS59	Unnamed stream (tributary to Bertrand Creek)	NW¼ sec.18, T.40N., R.3E., at Lynden-Sumas Road crossing, 1½ miles northwest of Lynden.	1.06	1122, 1152, 1346, 1396	0.02	Oct. 1, 1954
NS60	Bertrand Creek	North line sec.27, T.40N., R.2E., at Birch Bay-Lynden Road crossing, 3½ miles west of Lynden.	33.8	982, 1012, 1346, 1396	8.96	Oct. 12, 1943
NS61	Bellingar Ditch	NE¼NE¼ sec.5, T.39N., R.3E., at Hannegan Road crossing, 3 miles south of Lynden.	0.47	1346	0.05	Sept. 14, 1954
NS62	Wiser Lake Creek	SW¼ sec.3, T.39N., R.2E., ½ mile above mouth and 3 miles northeast of Ferndale.	6.23	962, 982, 1152, 1346, 1396, 1566, 1636	1.04	Aug. 18, 1958
NS63	Unnamed stream (tributary to Tenmile Creek)	N½ sec.27, T.39N., R.3E., at Starry Road crossing, 3½ miles southeast of Laurel.	0.71	1346	0	Sept. 14, 29, 1954
NS64	Tenmile Creek	NE¼ sec.18, T.39N., R.3E., at road crossing, 1 mile northeast of Laurel.	10.1	1122, 1152, 1346, 1396, 1446, 1566, 1636	0.69	Aug. 18, 1958
NS65	Tenmile Creek	East line sec.13, T.39N., R.2E., at State Highway crossing 3/4 mile north of Laurel.	12.1	962, 982	1.36	Aug. 17, 1942
NS66	Unnamed stream (tributary to Green Lake)	North line sec.10, T.39N., R.3E., at Pole Road crossing, 4 miles southeast of Lynden.	0.31	1346	0.88	Sept. 14, 1954
NS67	Fourmile Creek	West line sec.9, T.39N., R.3E., at Hannegan Road crossing, 4½ miles south of Lynden.	8.30	1346	1.53	Sept. 14, 1954
NS68	Fourmile Creek	W½ sec.18, T.39N., R.3E., at road crossing, 1 mile north of Laurel.	10.0	1122, 1152, 1346	2.30	Oct. 1, 1954
NS69	Fourmile Creek	SE¼ sec.13, T.39N., R.2E., at State Highway crossing, 3/4 mile north of Laurel.	10.6	962, 982	2.19	Oct. 12, 1942
2130	Tenmile Creek	NE¼SW¼ sec.22, T.39N., R.2E., at former gaging station site near Ferndale.	25.7	1122, 1152, 1216, 1396, 1446, 1566	1.64	Aug. 18, 1958
NS70	Larrabee Springs	NW¼NW¼ sec.36, T.39N., R.2E., 100 ft below source, 2 miles southwest of Laurel.	0.07	982, 1122, 1152, 1182, 1346, 1396, 1446, 1636	0.31	Sept. 7, 1956

Table 3. Miscellaneous Low Flow Discharge Measurements. (Continued)

Map No.	Stream	Location	Drain. area (sq mi)	Publication (WSP)	Minimum discharge measured	
					Cfs	Date
	NOOKSACK RIVER DRAINAGE BASIN (continued)					
NS71	Deer Creek	NE¼ sec.27, T.39N., R.2E., at road crossing, 2 miles east of Ferndale.	6.45	982, 1152, 1346, 1396, 1446, 1566, 1636	0.82	Aug. 18, 1958
NS72	Barrett Lake Outlet	SE¼ sec.20, T.39N., R.2E., at road crossing, 1 mile east of Ferndale.	33.9	1346	9.67	Sept. 10, 1954
	COASTAL AREA BASINS					
	Silver Creek Basin					
SL1	Silver Creek	SE¼ sec.34, T.39N., R.2E., at Sunset Road crossing, 1½ miles east of Brennan.	7.59	1122, 1152, 1346	0.10	Sept. 9, 1954
	Terrell Creek Basin					
TR1	Terrell Creek	Center sec.9, T.39N., R.1E., at Kickerville.	5.93	982, 1346	0	July 23, 1943, Sept. 30, 1954
TR2	Fingalson Creek	South line sec.3, T.39N., R.1E., at road crossing, 4 miles northwest of Ferndale.	0.84	1122, 1346	0	Sept. 20, 1948, Sept. 9, 1954
TR3	Terrell Creek	East line sec.6, T.39N., R.1E., at road crossing, 6 miles south of Blaine.	8.29	1346, 1396, 1446, 1566 1636	0	Sept. 30, 1954, Aug. 7, Sept. 6, 1956, Aug. 19, 1958
TR4	Terrell Creek	West line sec.6, T.39N., R.1E., at road crossing, 6 miles south of Blaine.	12.4	1122, 1346	0	Sept. 20, 1948
	California Creek Basin					
2135	California Creek	SE¼SE¼ sec.27, T.40N., R.1E., at Porter Road crossing, at gaging station site.	11.0	962, 982, 1346, 1566	0.33	Aug. 19, 1958
CL1	California Creek	SE¼ sec.21, T.40N., R.1E., at road crossing, 4 miles southeast of Blaine.	18.1	1122, 1152, 1346, 1636	1.19	Sept. 30, 1954
	Dakota Creek Basin					
DK1	North Fork Dakota Creek	SE¼SE¼ sec.14, T.40N., R.1E., at road crossing, 5 miles southeast of Blaine.	7.90	1122, 1152, 1346, 1396, 1446, 1566, 1636	0.56	Aug. 7, 1956
DK2	South Fork Dakota Creek	SE¼SE¼ sec.14, T.40N., R.1E., at road crossing, 5 miles southeast of Blaine.	7.67	1122, 1152, 1346	0.47	Aug. 16, 1949
DK3	Haynie Creek	SE¼ sec.10, T.40N., R.1E., at road crossing, 4 miles east of Blaine.	1.73	1122, 1346	0.27	Sept. 30, 1954
DK4	Unnamed stream (tributary to Dakota Creek)	SE¼ sec.9, T.40N., R.1E., at road crossing, 2 miles east of Blaine.	1.61	1122, 1346	0.38	Sept. 10. 1954
DK5	Unnamed stream (tributary to Dakota Creek)	About center W½ sec.9, T.40N., R.1E., at road crossing, 2 miles east of Blaine.	1.26	1122, 1346	0.08	Sept. 10, 1954
DK6	Spooner Creek	South line sec.5, T.40N., R.1E., at road crossing, 1½ miles east of Blaine.	1.43	1122, 1346	0.04	Sept. 10, 1954

Table 3. Miscellaneous Low Flow Discharge Measurements. (Continued)

Map No.	Stream	Location	Drain. area (sq mi)	Publication (WSP)	Minimum discharge measured	
					Cfs	Date
	SUMAS RIVER BASIN					
SM1	Sumas River	SE¼ sec.16, T.39N., R.4E., at road crossing, ½ mile north of Lawrence.	1.79	1092, 1346	0	Sept. 4, 1947, Sept. 9, Oct. 1, 1954
SM2	Sumas River	West line sec.9, T.39N., R.4E., at road crossing, 2 miles north of Lawrence.	3.47	1122, 1346	0	Sept. 20, 1948, Sept. 9, Oct. 1, 1954
SM3	Dale Creek	North line sec.9, T.39N., R.4E., at road crossing, 2½ miles southeast of Nooksack.	1.49	1092, 1122, 1346, 1396, 1446, 1566, 1636	0	Sept. 4, 1947
SM4	Goodwin Ditch	SW¼ sec.33, T.40N., R.4E., at road crossing, 1 mile southeast of Nooksack.	3.05	1092, 1122, 1346, 1396, 1446, 1636	2.59	Sept. 4, 1947
SM5	Sumas River	South line NE¼ sec.32, T.40N., R. 4E., at farm bridge, 1 mile southeast of Nooksack.	8.38	1092	9.19	Sept. 4, 1947
SM6	Swift Creek	NW¼ sec.33, T.40N., R.4E., at road crossing, 3/4 mile east of Nooksack.	3.12	1092, 1122, 1346, 1396 1446, 1636	0	Aug. 11, 1959
SM7	Sumas River	South line sec.29, T.40N., R.4E., at road crossing at Nooksack.	15.0	1122, 1152, 1346, 1446, 1566	6.82	Aug. 21, 1958
SM8	Breckenridge Creek	East line sec.28, T.40N., R.4E., at Goodwin Road crossing, 1½ miles east of Nooksack.	5.37	1092, 1122, 1152, 1346, 1396, 1446, 1566, 1636	0.27	Aug. 21, 1958
SM9	Kinney Creek	NW¼ sec.22, T.40N., R.4E., at road crossing, 3 miles south of Sumas.	1.89	1092, 1122, 1346, 1396	0.12	Sept. 20, 1948
2145	Sumas River	NE¼ sec.11, T.40N., R.4E., at former gaging station site, near Sumas.	30.2	1122, 1152, 1182, 1216, 1346, 1396, 1446, 1566, 1636	7.96	Aug. 19, 1958
SM10	Bone Creek	South line sec.3, T.40N., R.4E., at road crossing, 1 mile southwest of Sumas.	1.23	1092, 1346	0	Sept. 5, 1947, Sept. 9, Oct. 1, 1954
SM11	Bone Creek	NW¼ sec.2, T.40N., R.4E., at road crossing at Sumas.	2.56	1122, 1346	0.10	Sept. 9, Oct. 1, 1954
SM12	Sumas River	South line sec.35, T.41N., R.4E., at road crossing, ½ mile east of Sumas.	33.6	1092	12.5	Sept. 5, 1947
SM13	Johnson Creek	South line sec.8, T.40N., R.4E., at road crossing, 1 mile south of Clearbrook.	5.87	1092, 1122, 1346	0	Sept. 5, 1947, Sept. 21, 1948, Sept. 10, 1954
SM14	Squaw Creek	South line sec.12, T.40N., R.3E., at road crossing, 2 miles southwest of Clearbrook.	1.92	1122, 1346, 1396	0.73	Oct. 1, 1954
SM15	Unnamed stream (tributary to Squaw Creek)	SW¼SW¼ sec.7, T.40N., R.4E., at Lynden-Sumas Road crossing, 1¼ miles southwest of Clearbrook.	0.40	1346	0.31	Sept. 14, 1954

Table 3. Miscellaneous Low Flow Discharge Measurements. (Continued)

Map No.	Stream	Location	Drain. area (sq mi)	Publication (WSP)	Minimum discharge measured	
					Cfs	Date
	SUMAS RIVER BASIN (continued)					
SM16	Squaw Creek	South line sec.7, T.40N., R.4E., at road crossing, 1½ miles southwest of Clearbrook.	3.53	1122, 1346, 1396	1.08	Oct. 1, 1954
SM17	Squaw Creek	West line sec.8, T.40N., R.4E., at road crossing, 3/4 mile south of Clearbrook.	3.80	1092, 1346 1396	0.81	Sept. 5, 1947
SM18	Pangborn Creek	SW¼ sec.5, T.40N., R.4E., at road crossing at Clearbrook.	3.02	1092, 1122, 1346, 1396, 1466, 1566, 1636	1.53	Sept. 5, 1947
SM19	Johnson Creek	South line sec.5, T.40N., R.4E., at road crossing, ¼ mile east of Clearbrook.	13.7	1122	8.31	July 21, 1948
SM20	Johnson Creek	South line sec.34, T.41N., R.4E., at Front Street crossing at Sumas.	17.4	1092	10.7	Sept. 5, 1947
2150	Johnson Creek	SE¼ sec.34, T.41N., R.4E., at Sumas Avenue crossing, at former gaging station site at Sumas.	20.4	1122, 1152, 1346, 1396, 1446, 1566	8.22	Aug. 24, 1955
SM21	Saar Creek	Center sec.12, T.40N., R.4E., at mouth of canyon, 1½ miles southeast of Sumas.	7.46	1122, 1152, 1346, 1396	1.89	Aug. 17, 1949
2155	Saar Creek	North line sec.6, T.40N., R.5E., at Rock Road crossing, at former gaging station site.	10.0	1346, 1396 1566, 1636	0	Aug. 19, 1958

Table 4. Ratio of annual discharge for South Fork Nooksack River.

Year	Ratio	Year	Ratio	Year	Ratio	Year	Ratio	Year	Ratio
1910	*1.18	1920	*0.93	1930	*0.67	1940	0.91	1950	1.26
1911	*0.91	1921	*1.26	1931	*0.75	1941	0.80	1951	1.15
1912	*0.98	1922	*0.89	1932	*1.10	1942	0.82	1952	0.86
1913	*1.11	1923	*0.93	1933	*1.41	1943	0.98	1953	0.92
1914	*0.98	1924	*0.89	1934	1.23	1944	0.67	1954	1.28
1915	*0.61	1925	*1.08	1935	1.08	1945	0.91	1955	1.06
1916	*1.19	1926	*0.69	1936	0.93	1946	1.12	1956	1.11
1917	*1.04	1927	*0.97	1937	0.84	1947	1.00	1957	0.94
1918	*1.25	1928	*1.14	1938	0.94	1948	1.11	1958	0.82
1919	*1.13	1929	*0.72	1939	1.01	1949	1.02	1959	1.25

*Based on long-term records for nearby streams.

Table 5. Ratio of seasonal (July to September) discharge for South Fork Nooksack River.

Year	Ratio	Year	Ratio	Year	Ratio	Year	Ratio	Year	Ratio
1910	*1.44	1920	*1.20	1930	*0.46	1940	0.34	1950	1.68
1911	*0.97	1921	*1.35	1931	*0.50	1941	1.08	1951	0.52
1912	*1.01	1922	*0.69	1932	*0.96	1942	0.58	1952	0.75
1913	*1.78	1923	*0.86	1933	*2.12	1943	1.02	1953	1.19
1914	*0.73	1924	*0.53	1934	0.81	1944	0.71	1954	2.01
1915	*0.36	1925	*0.60	1935	0.96	1945	0.80	1955	1.68
1916	*1.75	1926	*0.38	1936	0.79	1946	0.98	1956	1.32
1917	*2.08	1927	*1.16	1937	0.79	1947	0.85	1957	0.69
1918	*0.78	1928	*0.56	1938	0.44	1948	1.27	1958	0.51
1919	*1.06	1929	*0.66	1939	1.10	1949	1.50	1959	1.65

*Based on long-term records for nearby streams.

The data are shown in tabular and graphical form as (1) maximum and minimum daily discharge hydrographs, (2) maximum, minimum, and average monthly discharge bar graphs, and (3) flow-duration curves. The three forms of presentation are discussed briefly below and are followed by the graphical and tabular expressions of the data.

MAXIMUM-MINIMUM DAILY HYDROGRAPHS

The hydrographs of maximum and minimum daily discharge shown on pages 54 through 66 are based on the maximum and minimum daily discharge for each date of the year throughout the period of record. The extremes of discharge thus plotted delineate a band within the boundaries of which every past daily discharge of record would lie if plotted. The hydrographs can be used to appraise the extremes of discharge to be expected throughout the year but do not define a record of continuous flow or typify the actual record for any individual year. The hydrographs approach the category of flow-duration graphs inasmuch as the minimum daily discharge hydrograph presents daily mean discharges that have been equaled or exceeded 100 percent of the time, while the maximum daily discharge hydrograph presents daily mean discharges that have not been exceeded at any time during the period of record. The discharge figures used for preparing these hydrographs are tabulated on pages 68-74.

MAXIMUM, MINIMUM, AND AVERAGE MONTHLY DISCHARGE BAR GRAPHS

The bar graphs shown on pages 54-66 and based on data listed on pages 75-78 are similar to the maximum-minimum hydrographs in that they show the maximum monthly discharge, the minimum monthly discharge, and the average of all the monthly discharges of record. These graphs appraise a stream's potential in more summarized form than do the daily maximum and minimum data.

FLOW-DURATION CURVES

Flow-duration curves show the percentage of time that specified discharges were equaled or exceeded during a given period.1/ Such curves are used to analyze the availability and variability of streamflow and to investigate problems of water supply, power development, waste disposal, and administration of water rights. A flow-duration curve for the entire period of record in itself does not show a chronological sequence of flow, but the curves for each month of the year as shown on pages 55 through 67 provide a substitute for the chronologic sequence of events. Such curves tend to define the frequency of occurrence of discharge at any given time of the year.

1/ Searcy, J. K. 1959, Flow duration curves manual of hydrology, pt. 2 of low flow techniques: U. S. Geol. Survey Water-Supply Paper 1542-A.

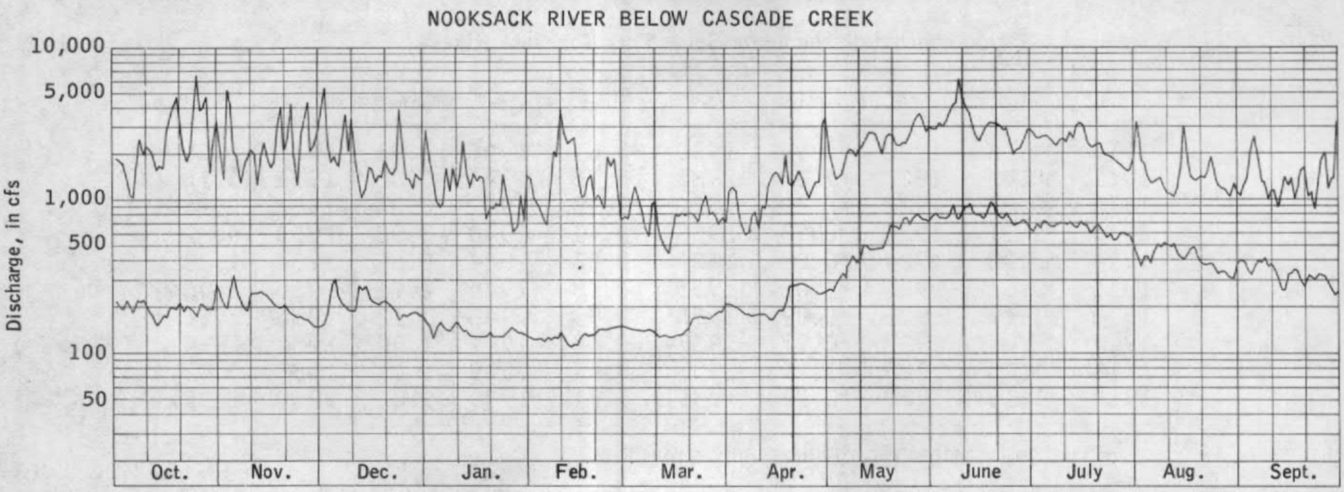


Figure 22. MAXIMUM-MINIMUM DISCHARGE HYDROGRAPHS FOR YEARS 1947-59.

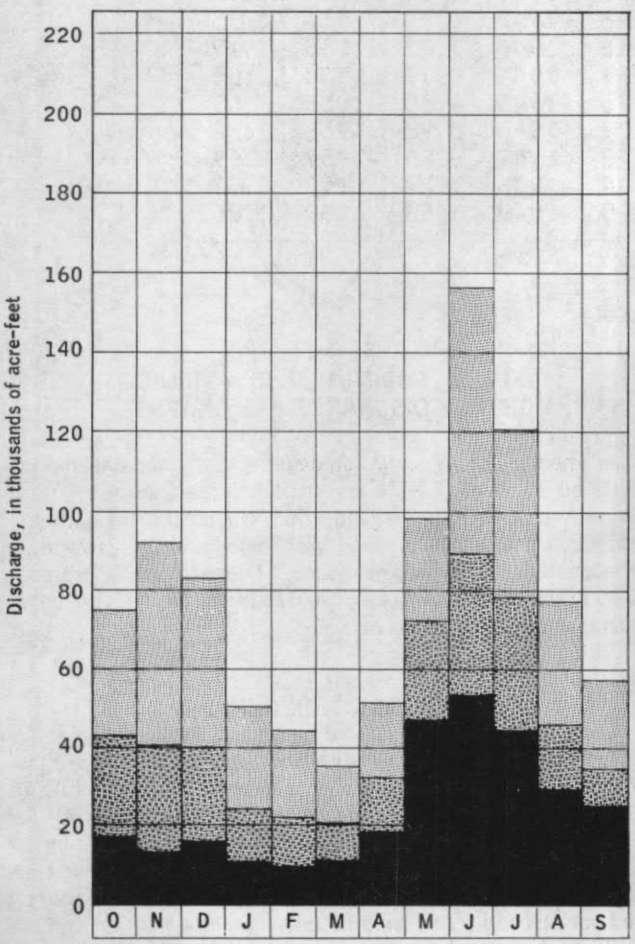


Figure 23. MAXIMUM, MINIMUM, AND AVERAGE MONTHLY DISCHARGE FOR THE PERIOD 1947-59.

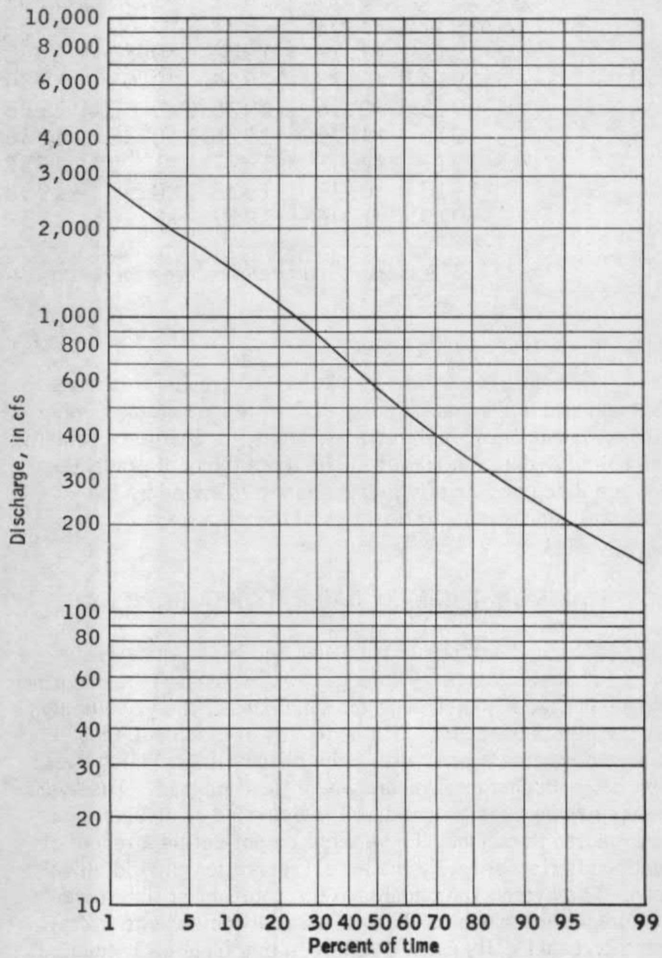


Figure 24. FLOW-DURATION CURVE FOR THE PERIOD 1938-59.

NOOKSACK RIVER BELOW CASCADE CREEK

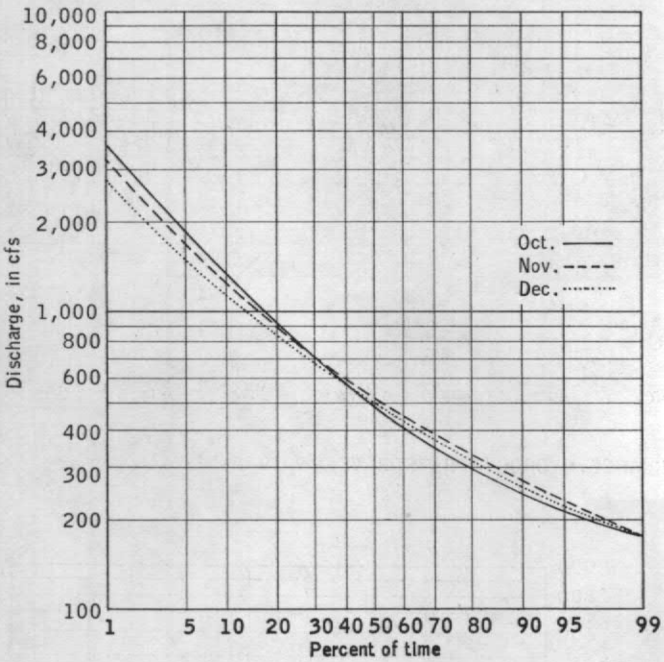


Figure 25a. FLOW-DURATION CURVES FOR OCTOBER, NOVEMBER, DECEMBER 1938-59.

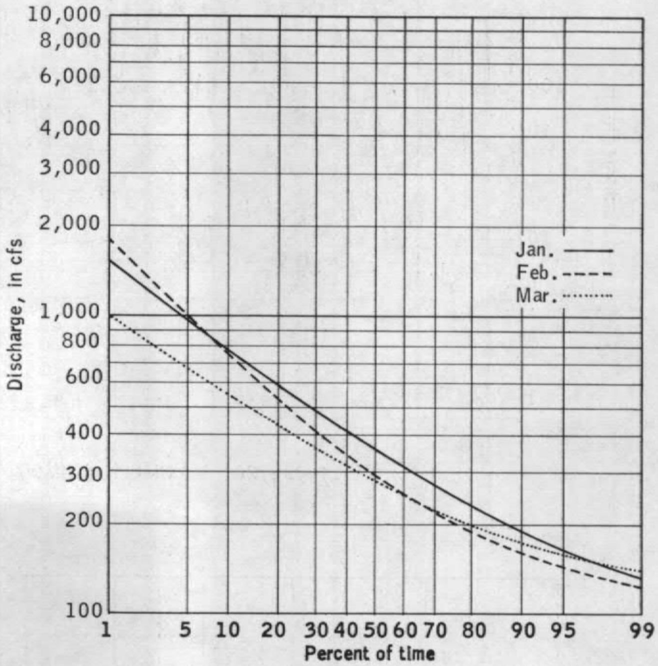


Figure 25b. FLOW-DURATION CURVES FOR JANUARY, FEBRUARY, MARCH 1938-59.

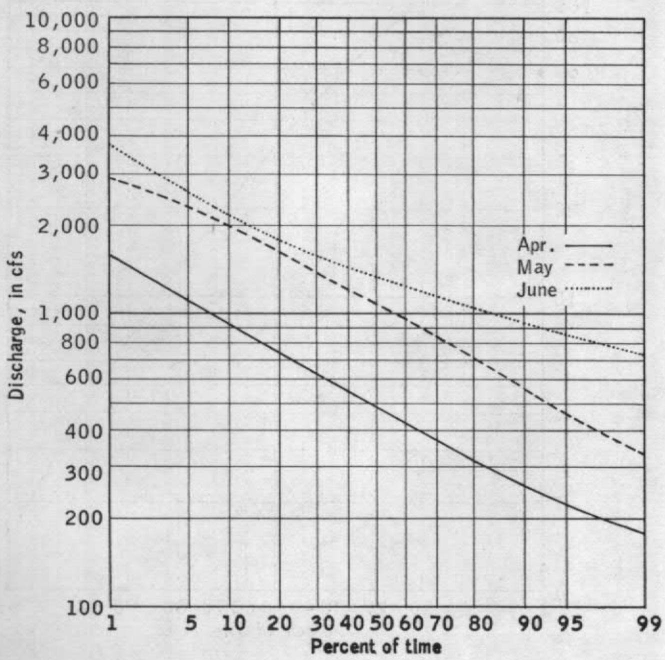


Figure 25c. FLOW-DURATION CURVES FOR APRIL, MAY, JUNE 1938-59.

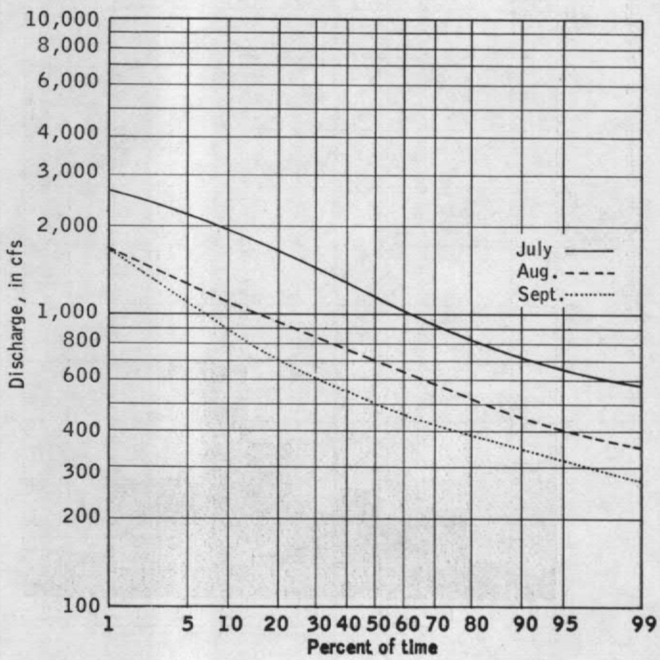


Figure 25d. FLOW-DURATION CURVES FOR JULY, AUGUST, SEPTEMBER 1938-59.

CANYON CREEK AT KULSHAN

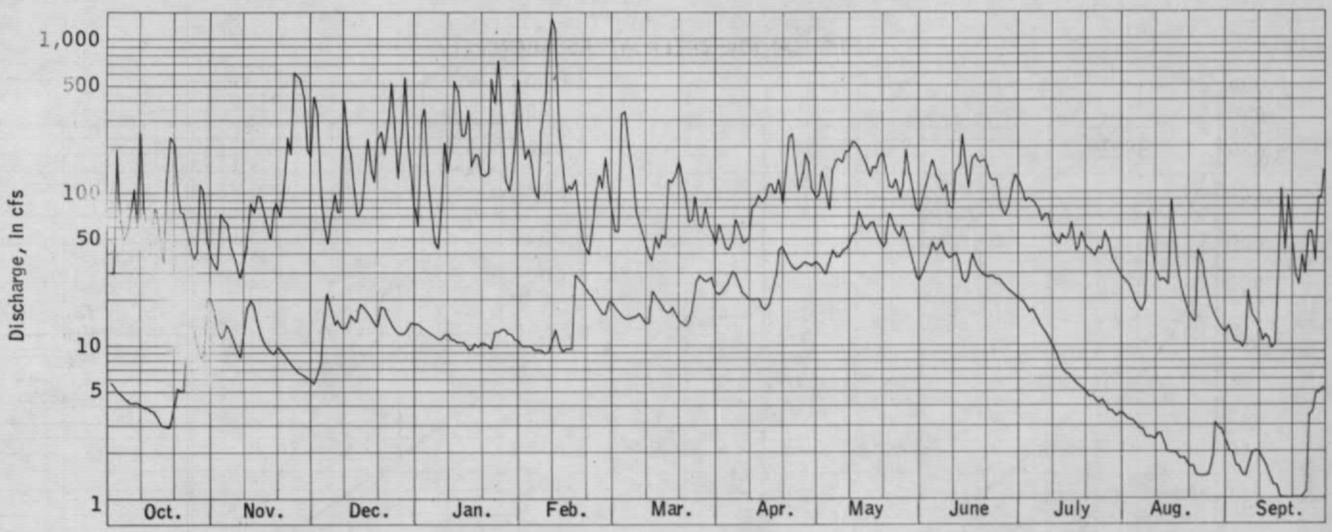


Figure 26. MAXIMUM-MINIMUM DISCHARGE HYDROGRAPHS FOR YEARS 1948-54.

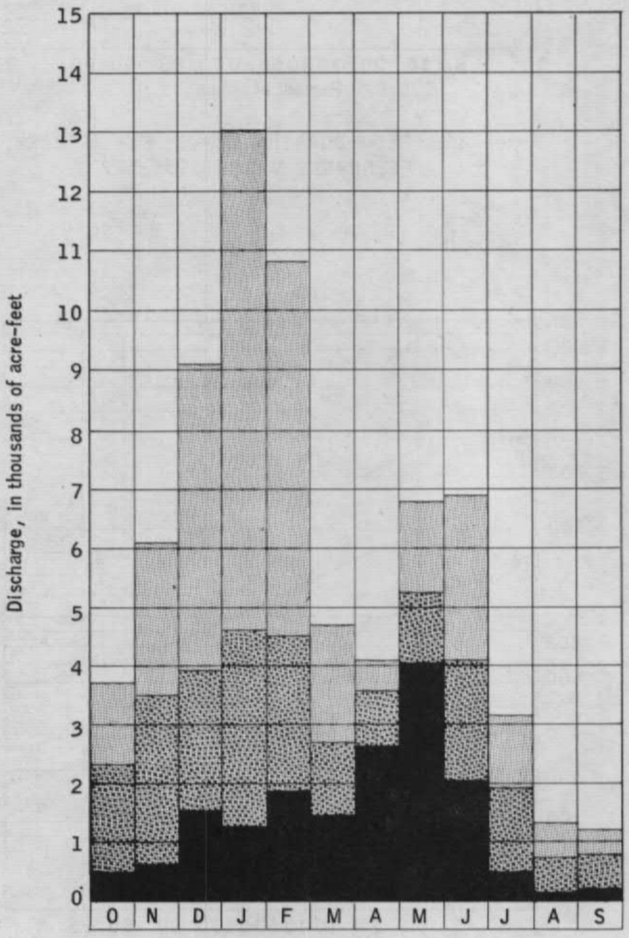


Figure 27. MAXIMUM, MINIMUM, AND AVERAGE MONTHLY DISCHARGE FOR THE PERIOD 1948-54.

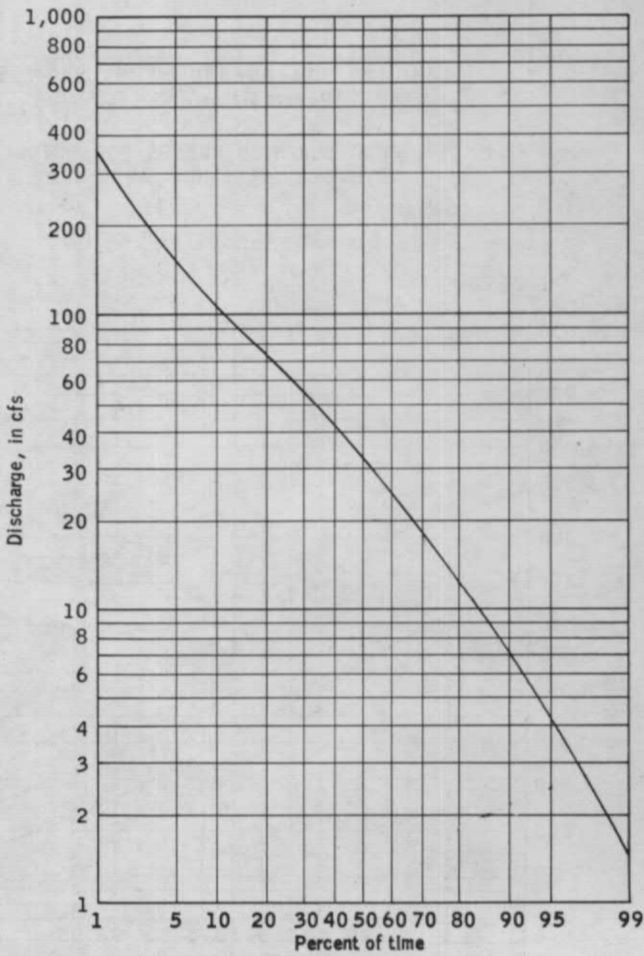


Figure 28. FLOW-DURATION CURVE FOR THE PERIOD 1949-53.

CANYON CREEK AT KULSHAN

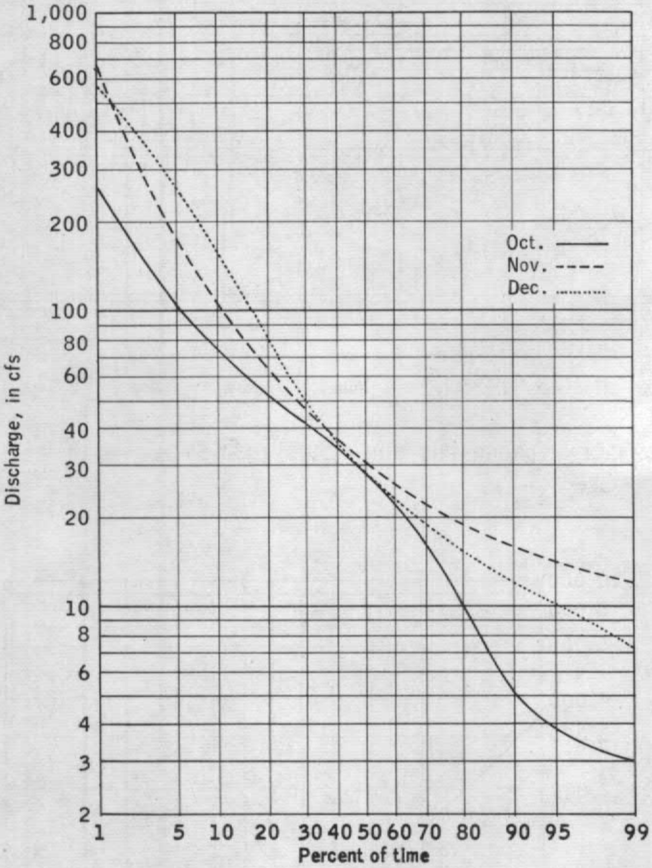


Figure 29a. FLOW-DURATION CURVES FOR OCTOBER, NOVEMBER, DECEMBER 1949-53.

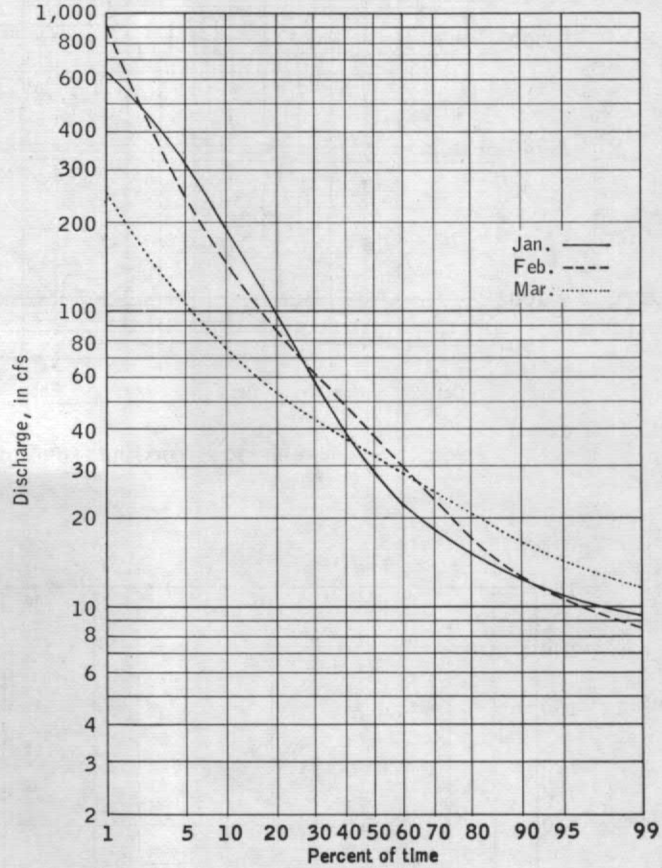


Figure 29b. FLOW-DURATION CURVES FOR JANUARY, FEBRUARY, MARCH 1949-53.

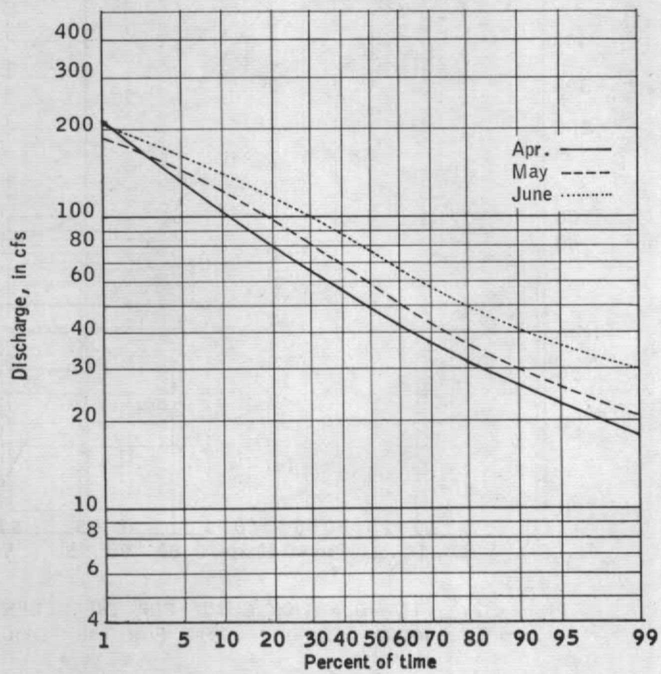


Figure 29c. FLOW-DURATION CURVES FOR APRIL, MAY, JUNE 1949-53.

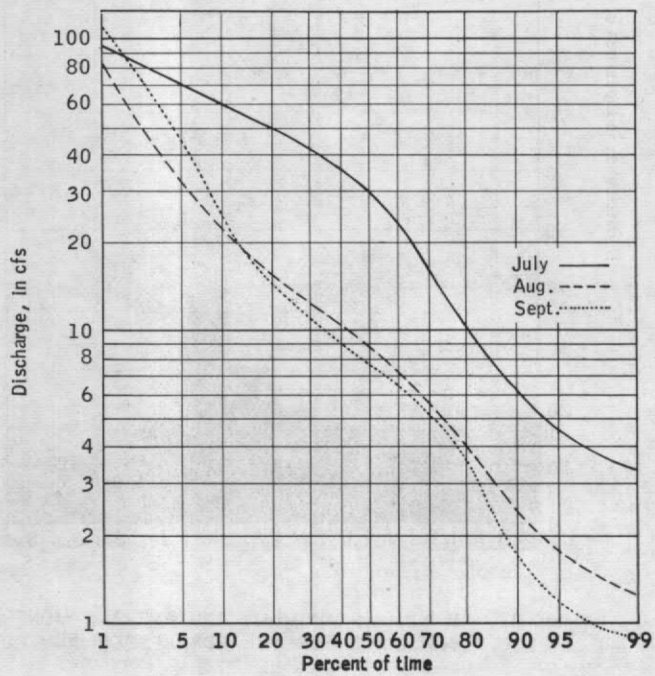


Figure 29d. FLOW-DURATION CURVES FOR JULY, AUGUST, SEPTEMBER 1949-53.

SOUTH FORK NOOKSACK RIVER NEAR WICKERSHAM

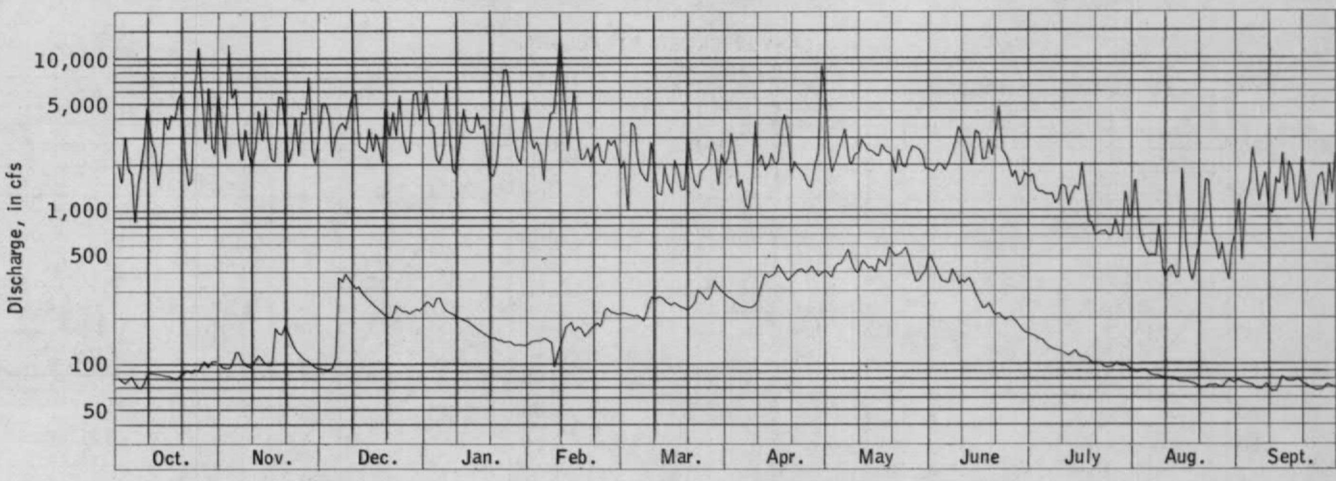


Figure 30. MAXIMUM-MINIMUM DISCHARGE HYDROGRAPHS FOR YEARS 1934-59.

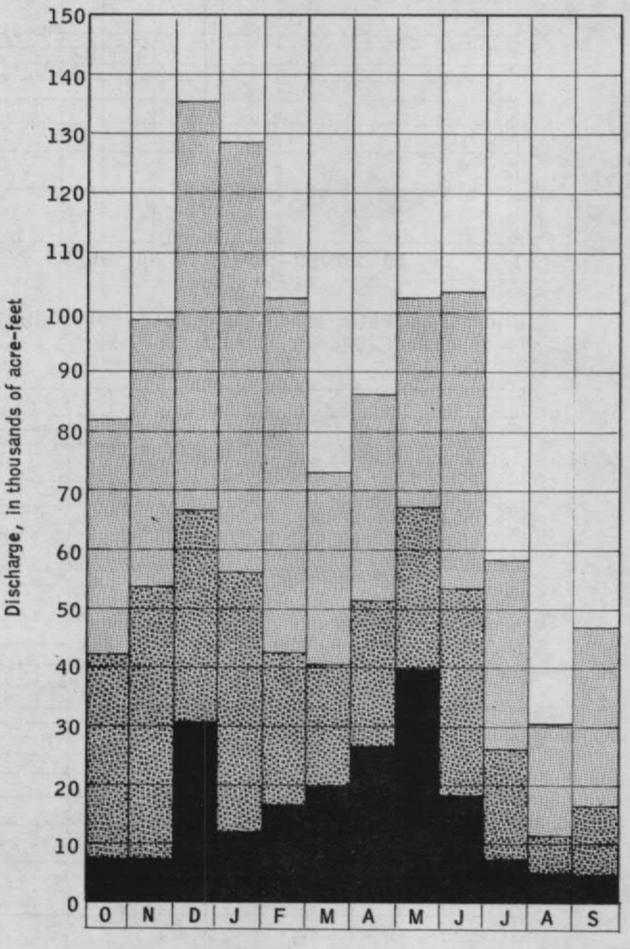


Figure 31. MAXIMUM, MINIMUM, AND AVERAGE MONTHLY DISCHARGE FOR THE PERIOD 1934-59.

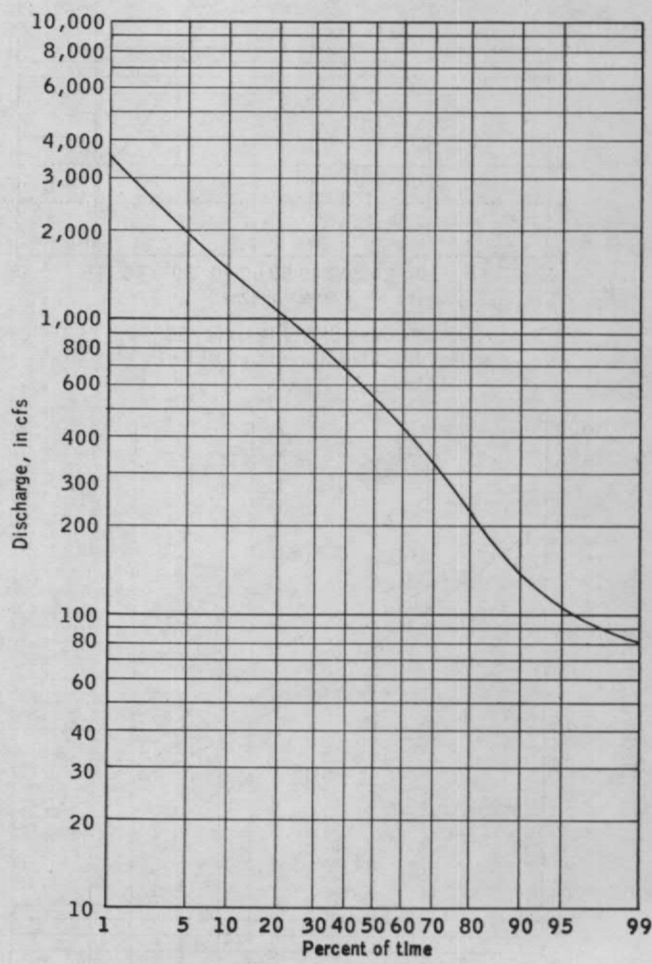


Figure 32. FLOW-DURATION CURVE FOR THE PERIOD 1935-59.

SOUTH FORK NOOKSACK RIVER NEAR WICKERSHAM

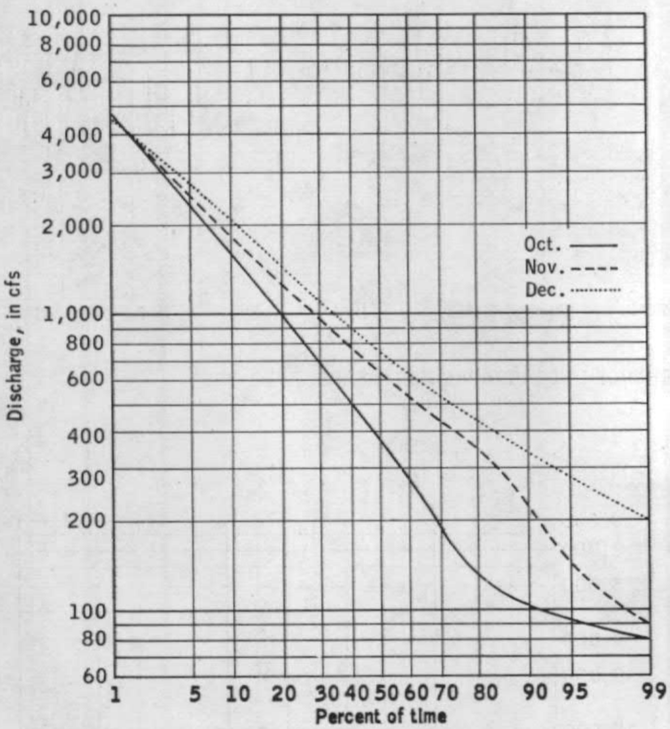


Figure 33a. FLOW-DURATION CURVES FOR OCTOBER, NOVEMBER, DECEMBER 1935-59.

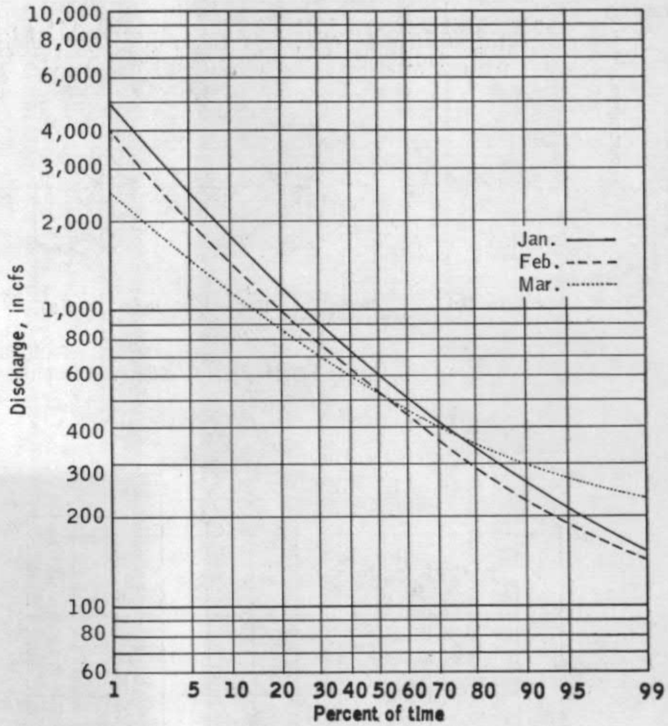


Figure 33b. FLOW-DURATION CURVES FOR JANUARY, FEBRUARY, MARCH 1935-59.

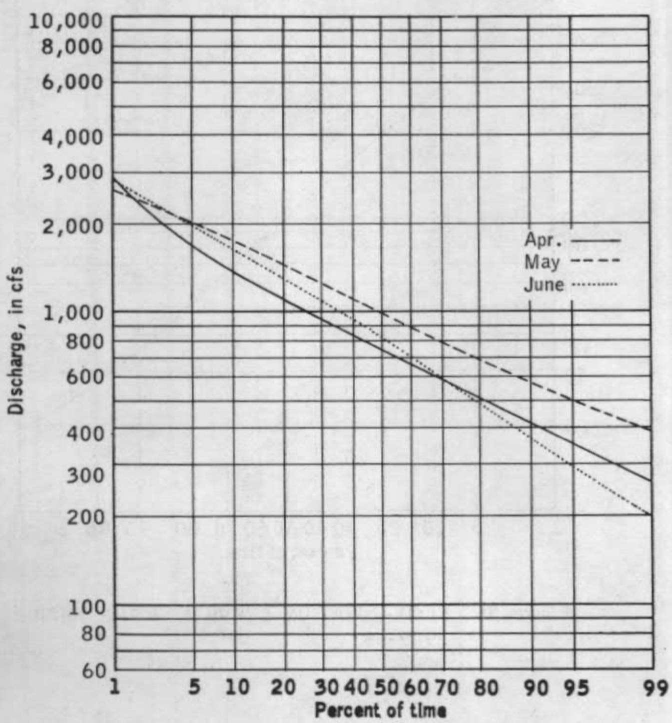


Figure 33c. FLOW-DURATION CURVES FOR APRIL, MAY, JUNE 1935-59.

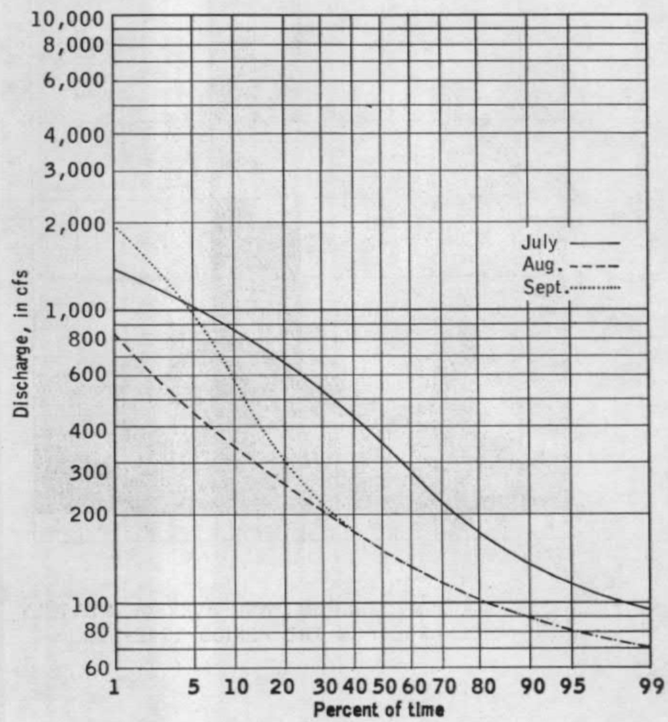


Figure 33d. FLOW-DURATION CURVES FOR JULY, AUGUST, SEPTEMBER 1935-59.

SKOOKUM CREEK NEAR WICKERSHAM

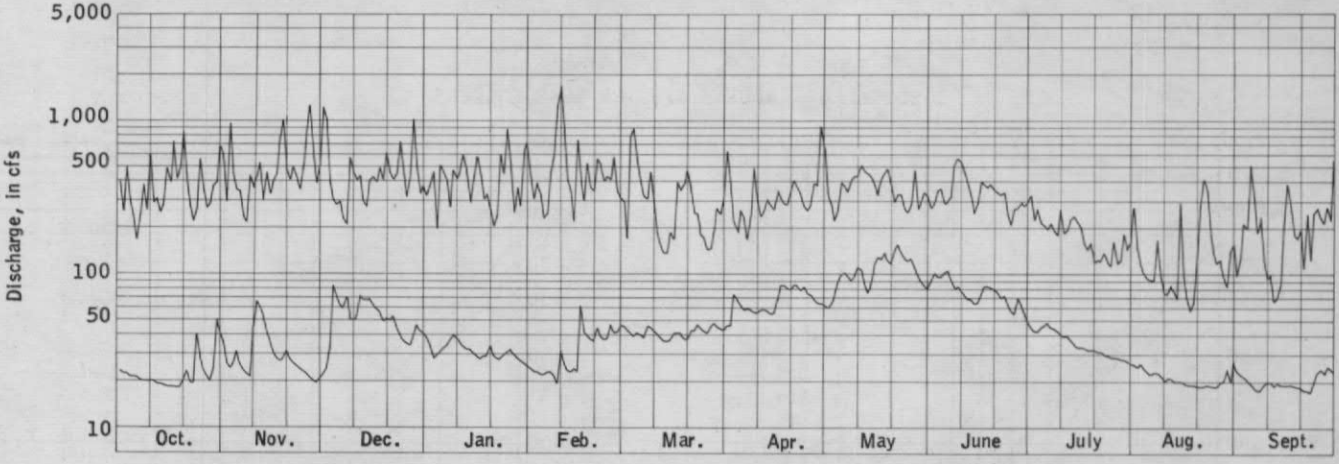


Figure 34. MAXIMUM-MINIMUM DISCHARGE HYDROGRAPHS FOR YEARS 1948-59.

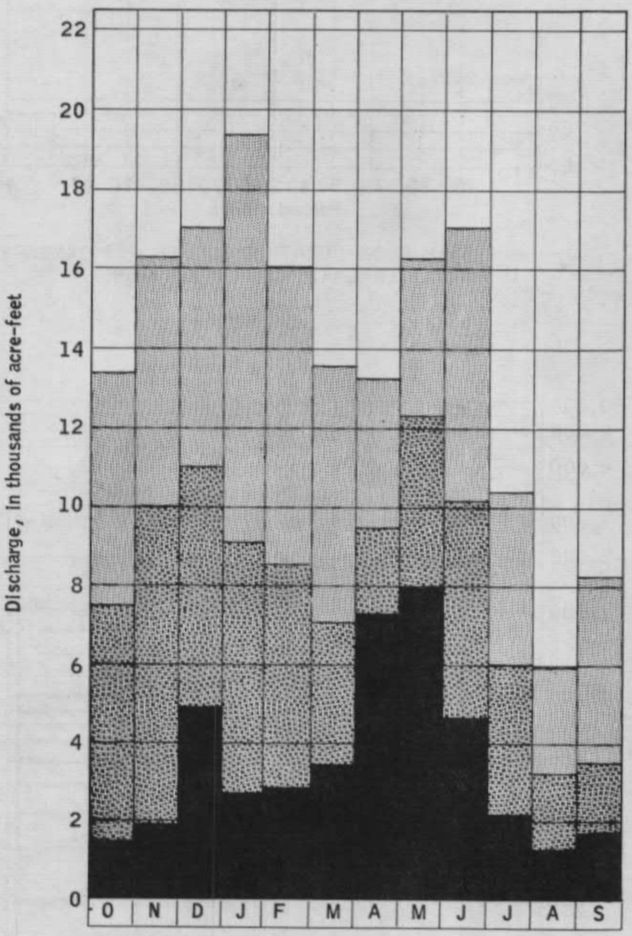


Figure 35. MAXIMUM, MINIMUM, AND AVERAGE MONTHLY DISCHARGE FOR THE PERIOD 1948-59.

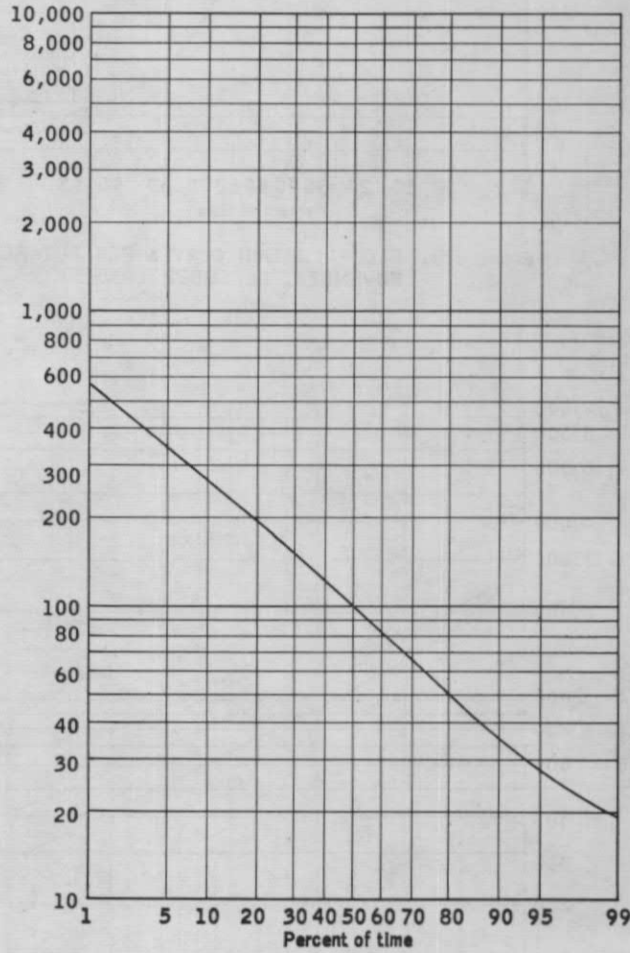


Figure 36. FLOW-DURATION CURVE FOR THE PERIOD 1949-59.

SKOOKUM CREEK NEAR WICKERSHAM

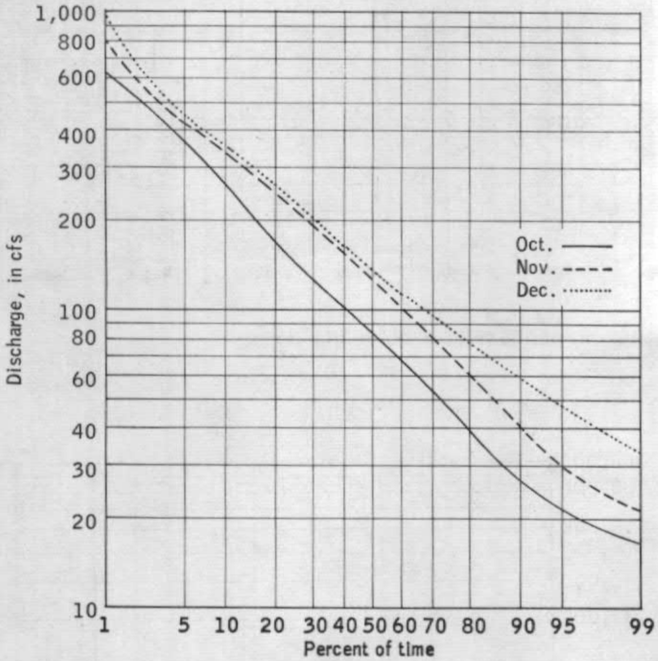


Figure 37a. FLOW-DURATION CURVES FOR OCTOBER, NOVEMBER, DECEMBER 1949-59.

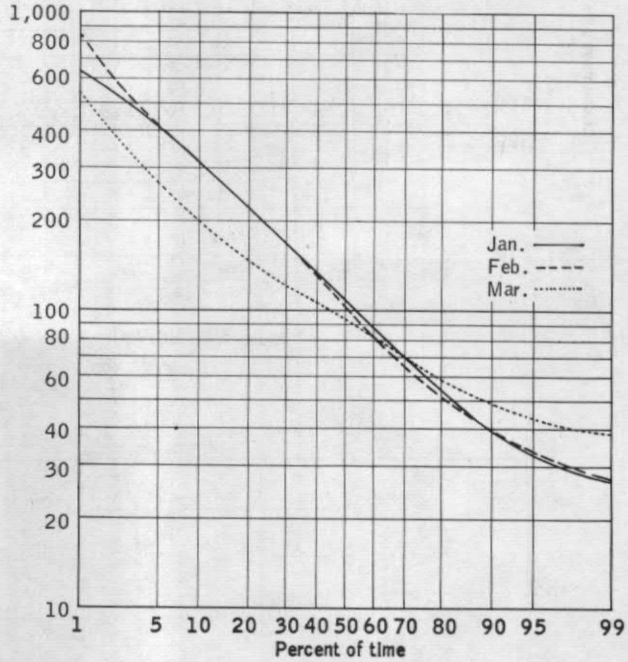


Figure 37b. FLOW-DURATION CURVES FOR JANUARY, FEBRUARY, MARCH 1949-59.

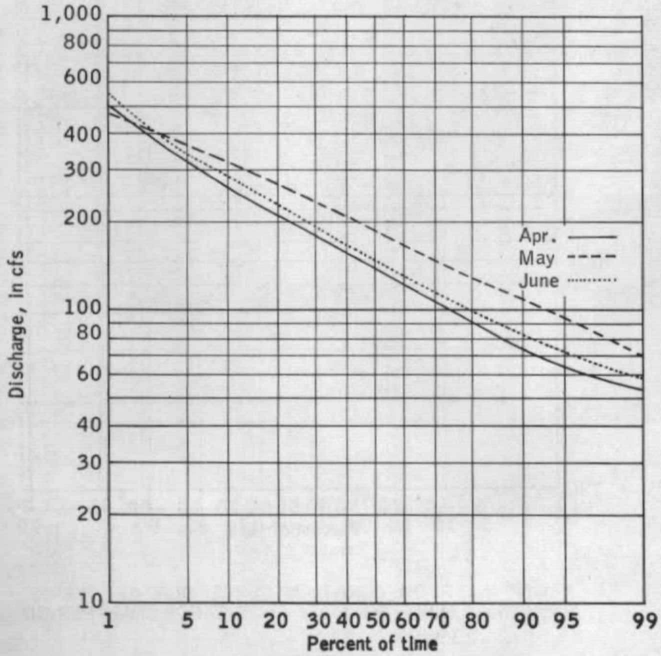


Figure 37c. FLOW-DURATION CURVES FOR APRIL, MAY, JUNE 1949-59.

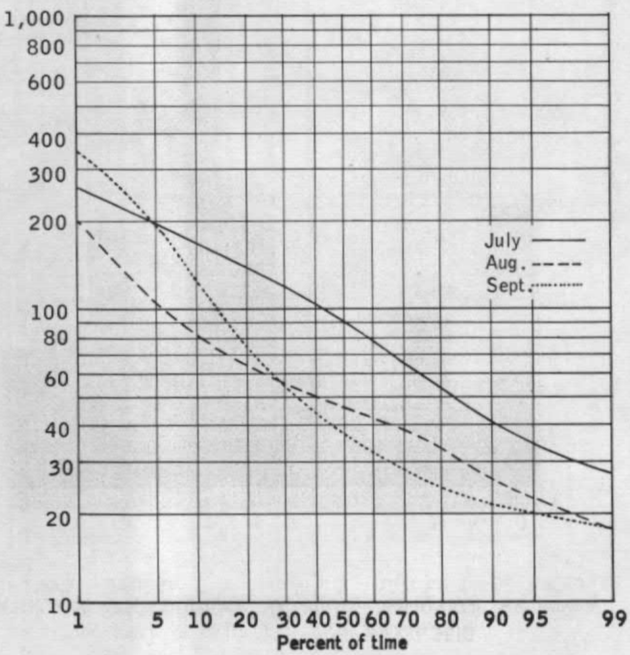


Figure 37d. FLOW-DURATION CURVES FOR JULY, AUGUST, SEPTEMBER 1949-59.

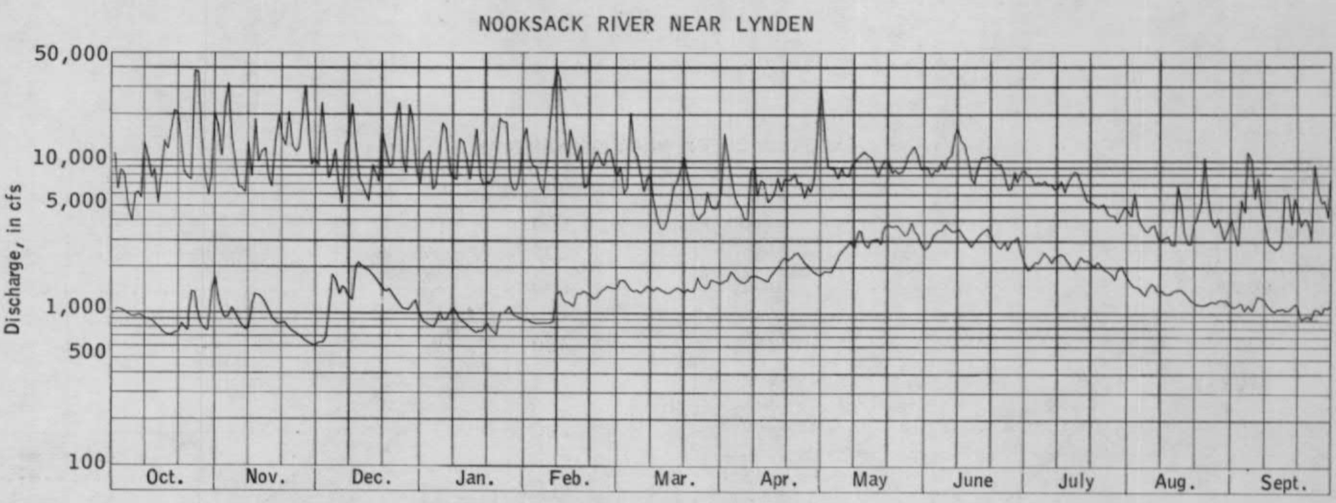


Figure 38. MAXIMIM-MINIMUM DISCHARGE HYDROGRAPHS FOR YEARS 1944-59.

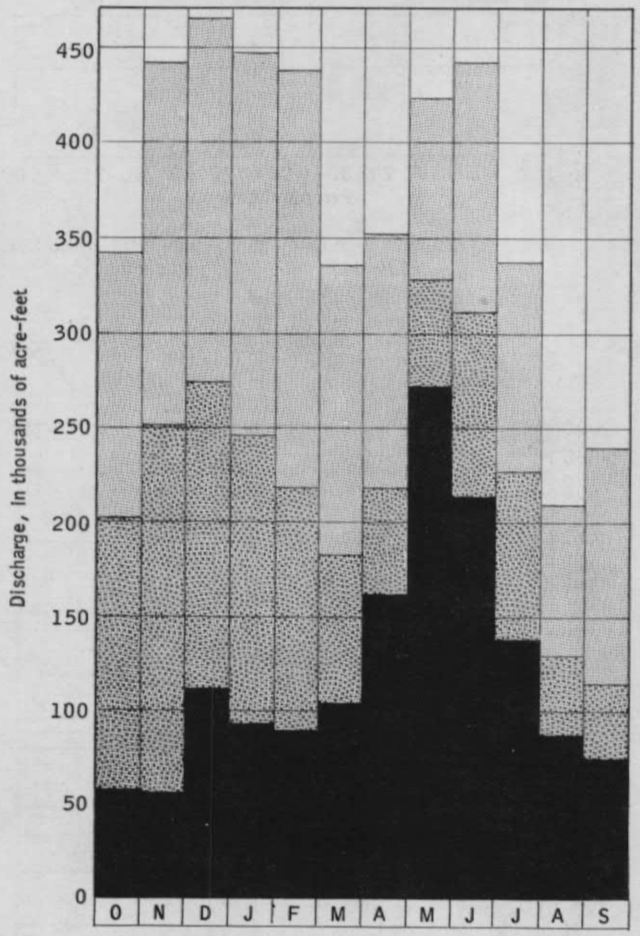


Figure 39. MAXIMUM, MINIMUM, AND AVERAGE MONTHLY DISCHARGE FOR THE PERIOD 1944-59.

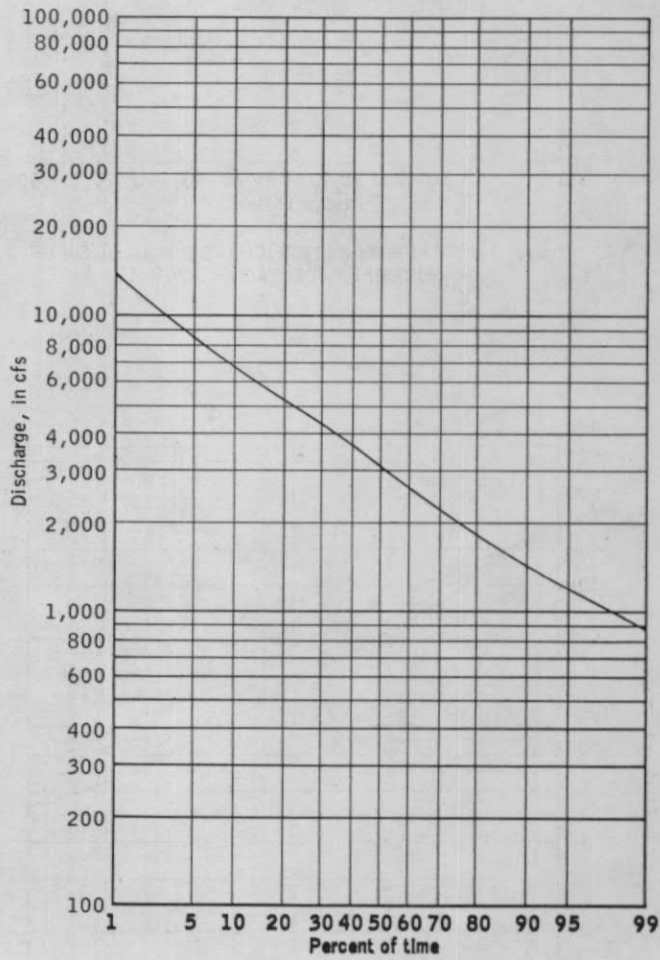


Figure 40. FLOW-DURATION CURVE FOR THE PERIOD 1946-59.

NOOKSACK RIVER NEAR LYNDEN

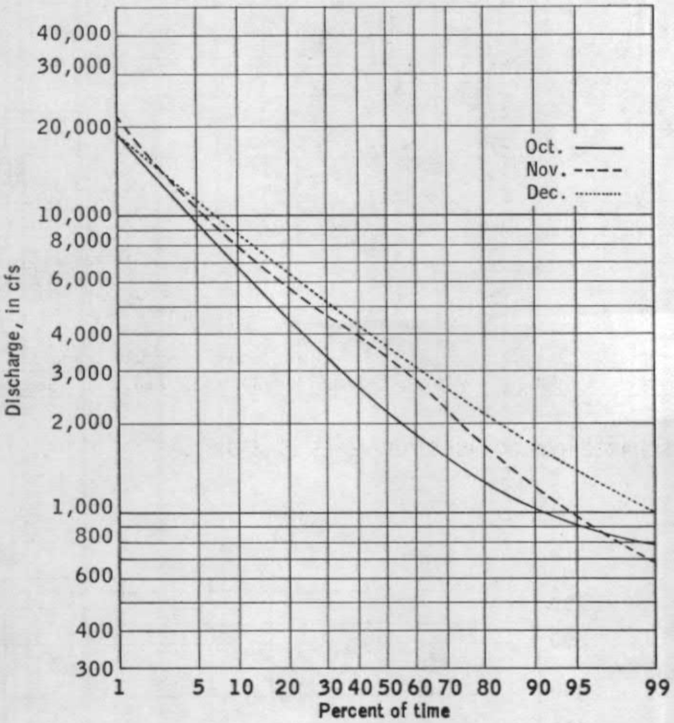


Figure 41a. FLOW-DURATION CURVES FOR OCTOBER, NOVEMBER, DECEMBER 1946-59.

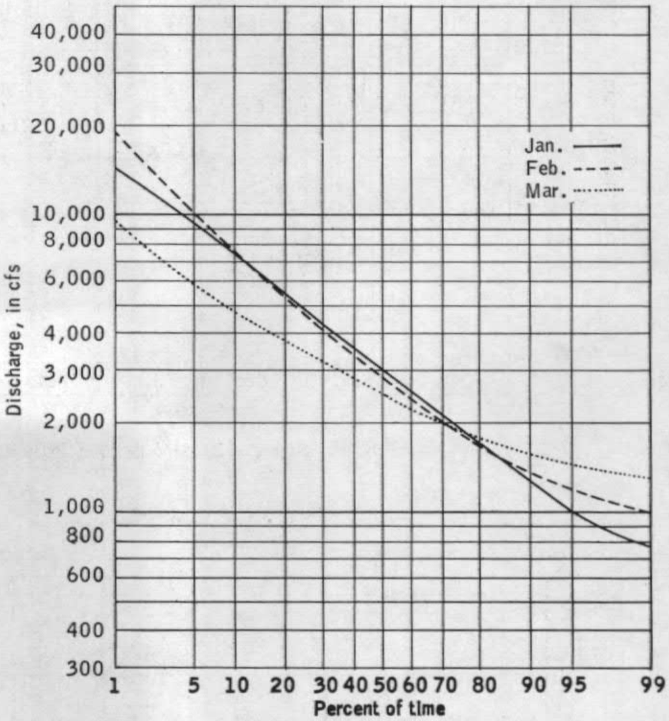


Figure 41b. FLOW-DURATION CURVES FOR JANUARY, FEBRUARY, MARCH 1946-59.

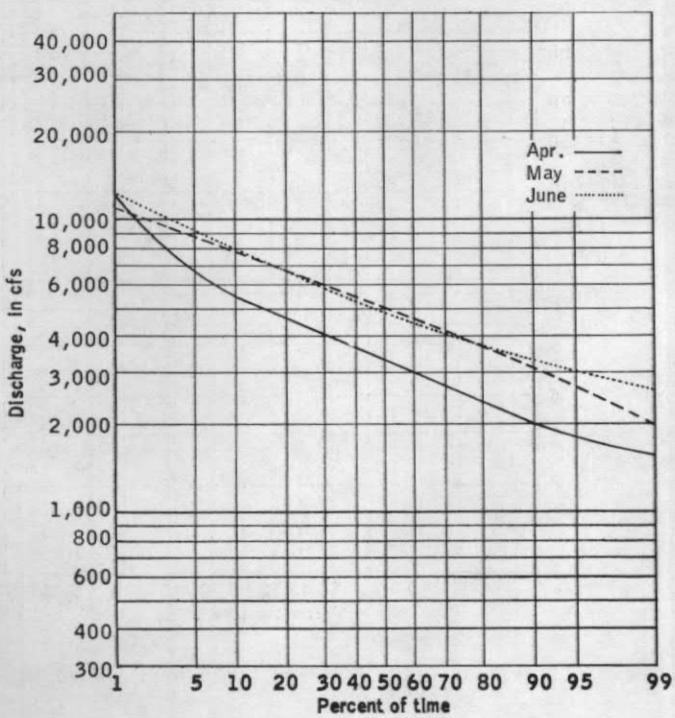


Figure 41c. FLOW-DURATION CURVES FOR APRIL, MAY, JUNE 1946-59.

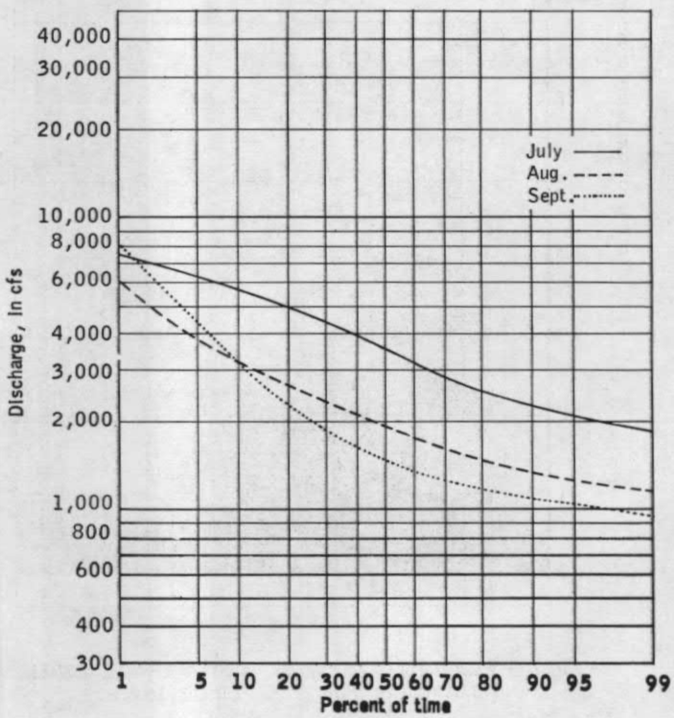


Figure 41d. FLOW-DURATION CURVES FOR JULY, AUGUST, SEPTEMBER 1946-59.

FISHTRAP CREEK AT LYNDEN

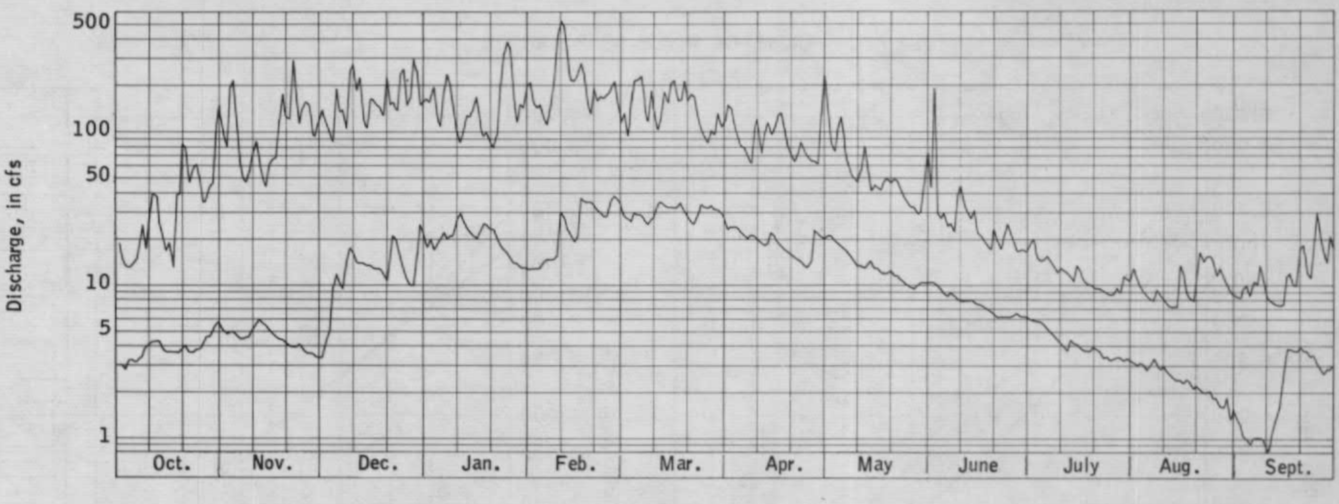


Figure 42. MAXIMUM-MINIMUM DISCHARGE HYDROGRAPHS FOR YEARS 1948-59.

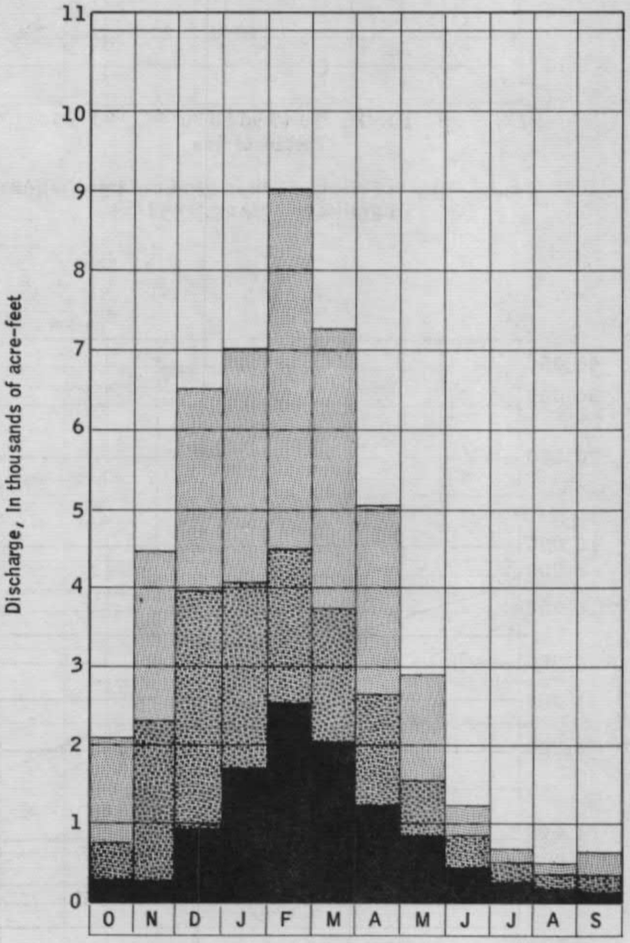


Figure 43. MAXIMUM, MINIMUM, AND AVERAGE MONTHLY DISCHARGE FOR THE PERIOD 1948-54.

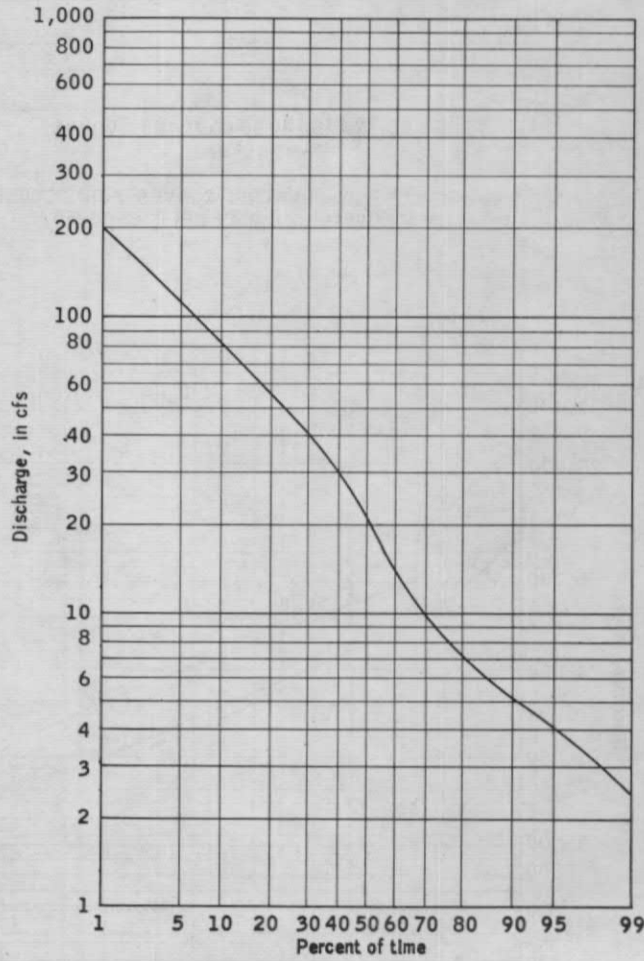


Figure 44. FLOW-DURATION CURVE FOR THE PERIOD 1949-59.

FISHTRAP CREEK AT LYNDEN

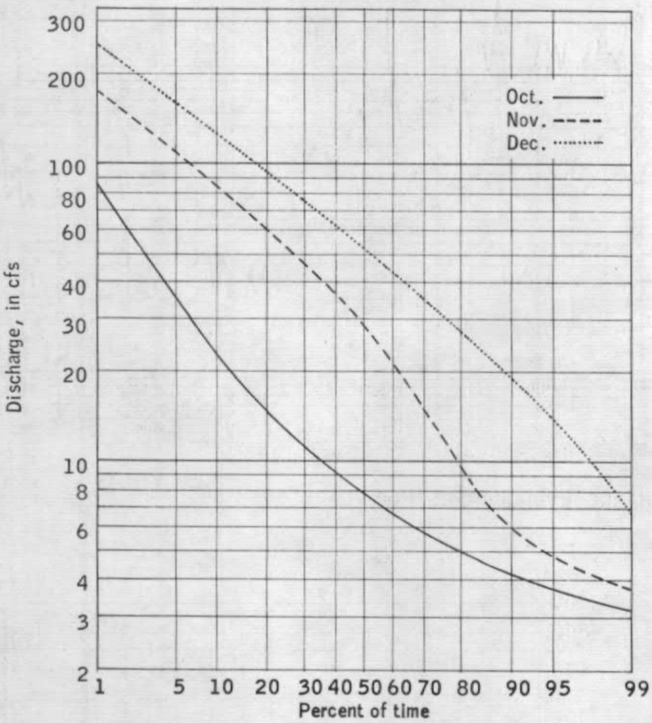


Figure 45a. FLOW-DURATION CURVES FOR OCTOBER, NOVEMBER, DECEMBER 1949-59.

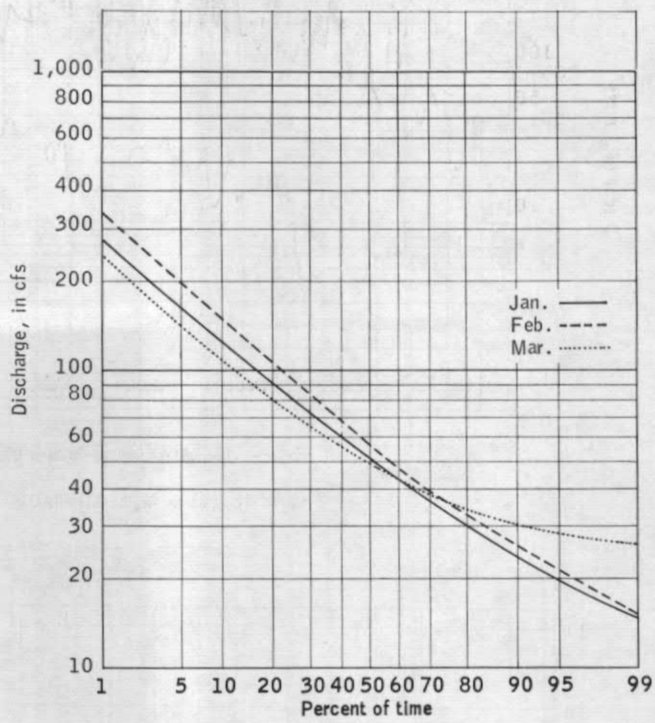


Figure 45b. FLOW-DURATION CURVES FOR JANUARY, FEBRUARY, MARCH 1949-59.

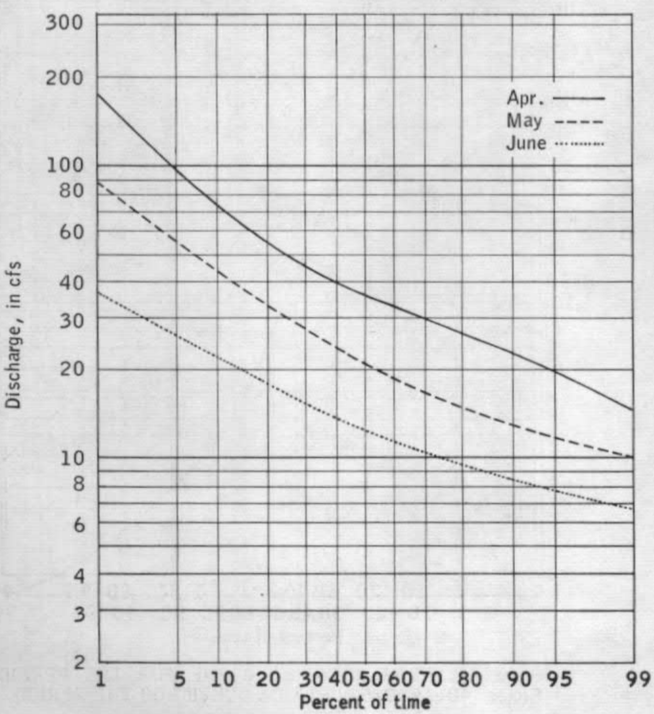


Figure 45c. FLOW-DURATION CURVES FOR APRIL, MAY, JUNE 1949-59.

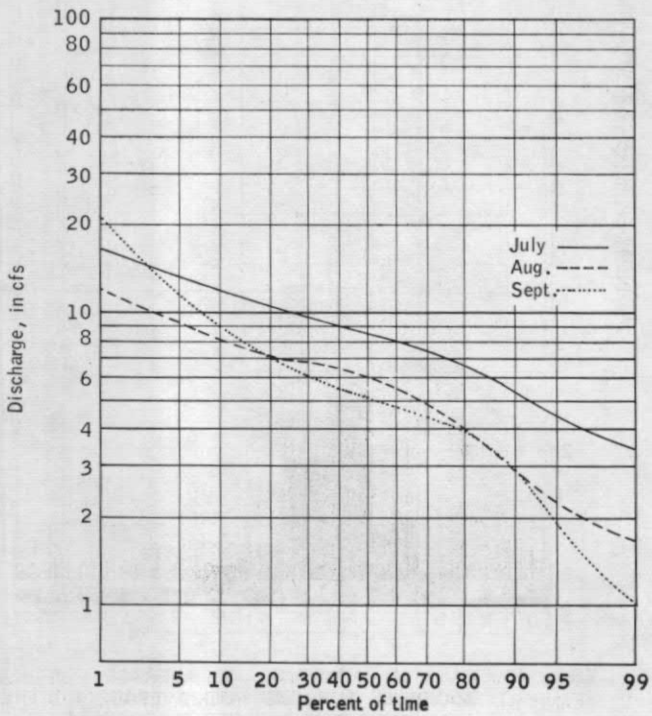


Figure 45d. FLOW-DURATION CURVES FOR JULY, AUGUST, SEPTEMBER 1949-59.

DAKOTA CREEK NEAR BLAINE

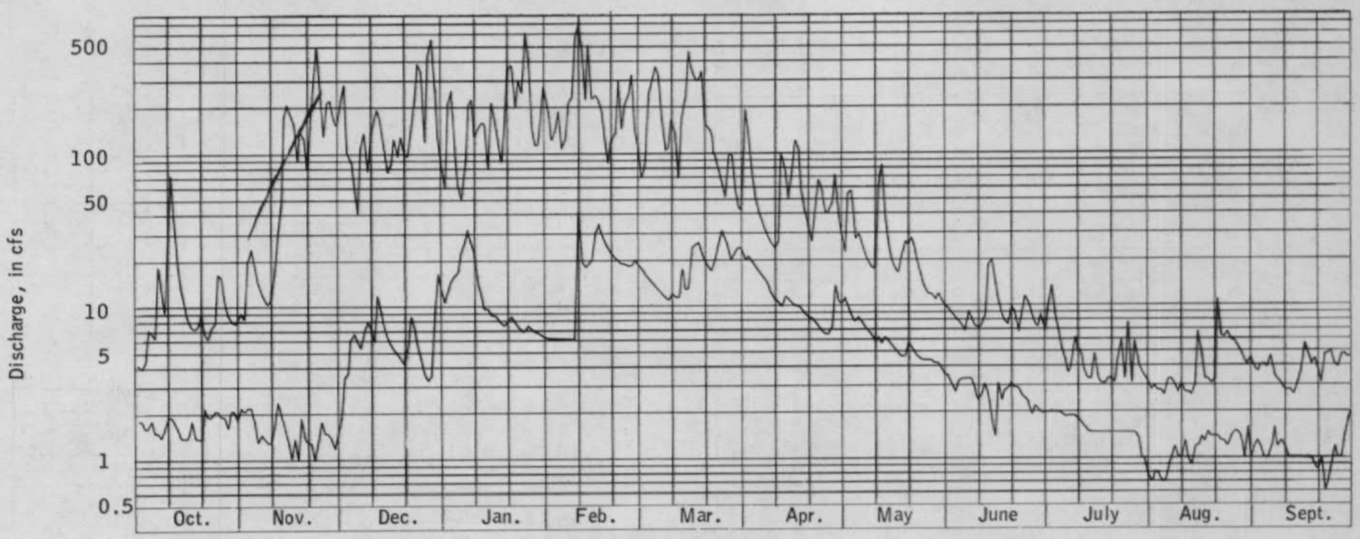


Figure 46. MAXIMUM-MINIMUM DISCHARGE HYDROGRAPHS FOR YEARS 1948-54.

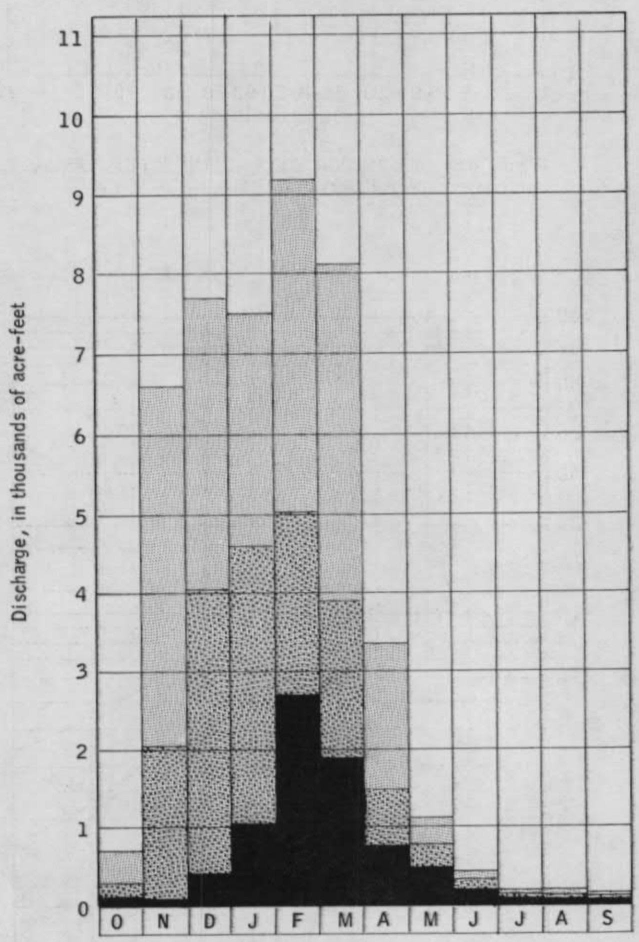


Figure 47. MAXIMUM, MINIMUM, AND AVERAGE MONTHLY DISCHARGE FOR THE PERIOD 1948-54.

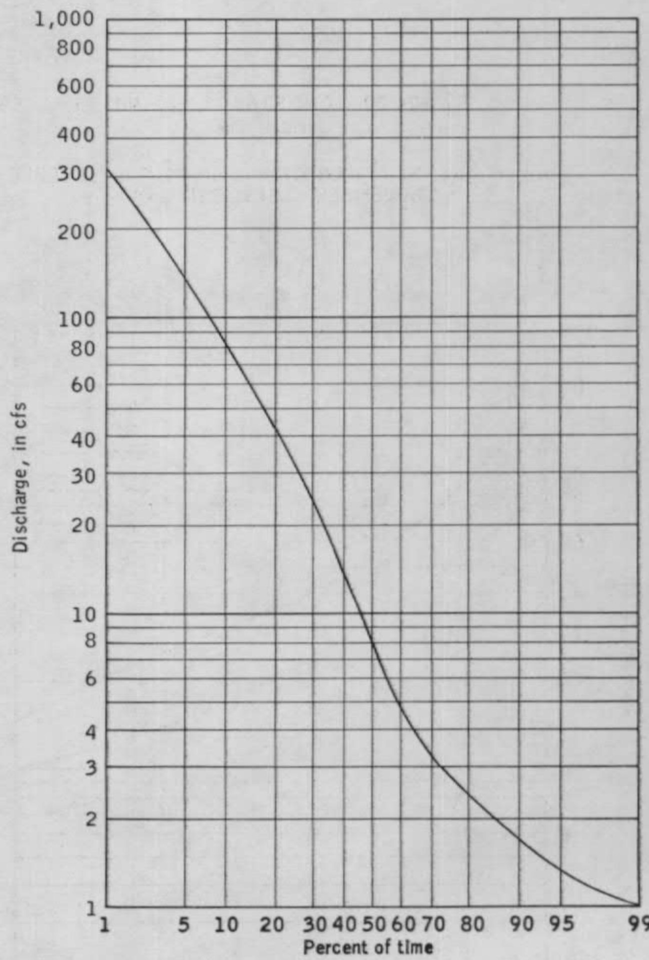


Figure 48. FLOW-DURATION CURVE FOR THE PERIOD 1945-53.

DAKOTA CREEK NEAR BLAINE

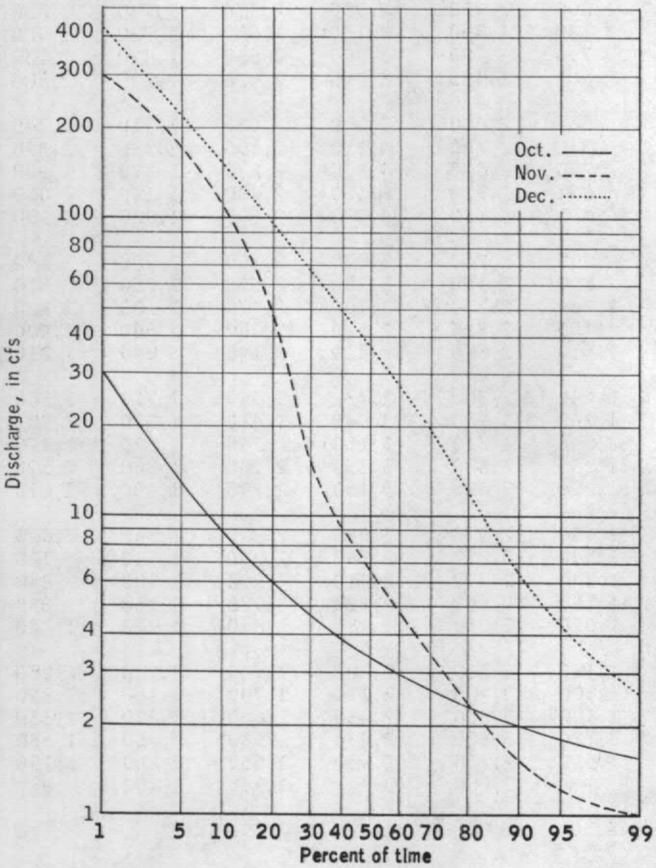


Figure 49a. FLOW-DURATION CURVES FOR OCTOBER, NOVEMBER, DECEMBER 1945-53.

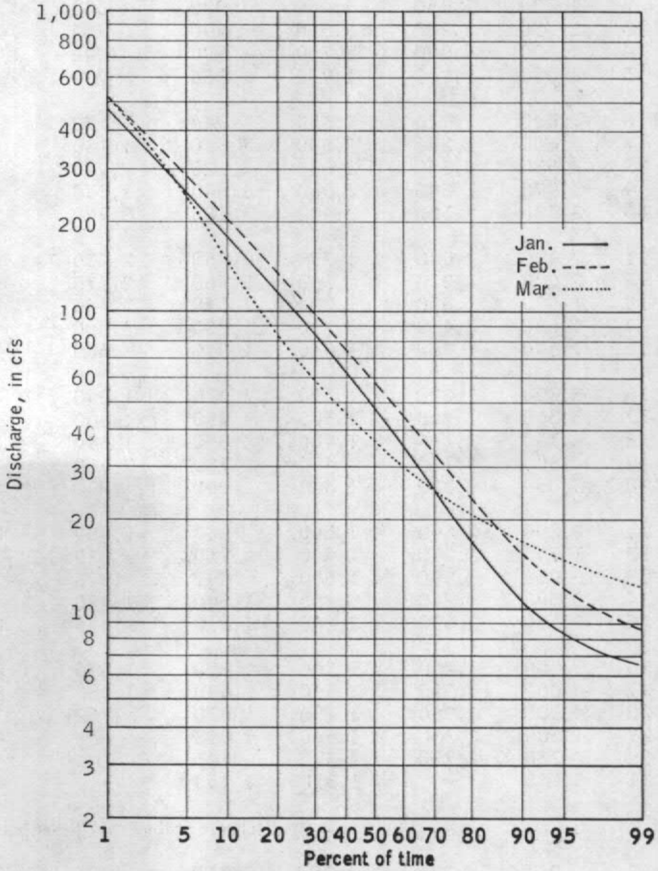


Figure 49b. FLOW-DURATION CURVES FOR JANUARY, FEBRUARY, MARCH 1945-53.

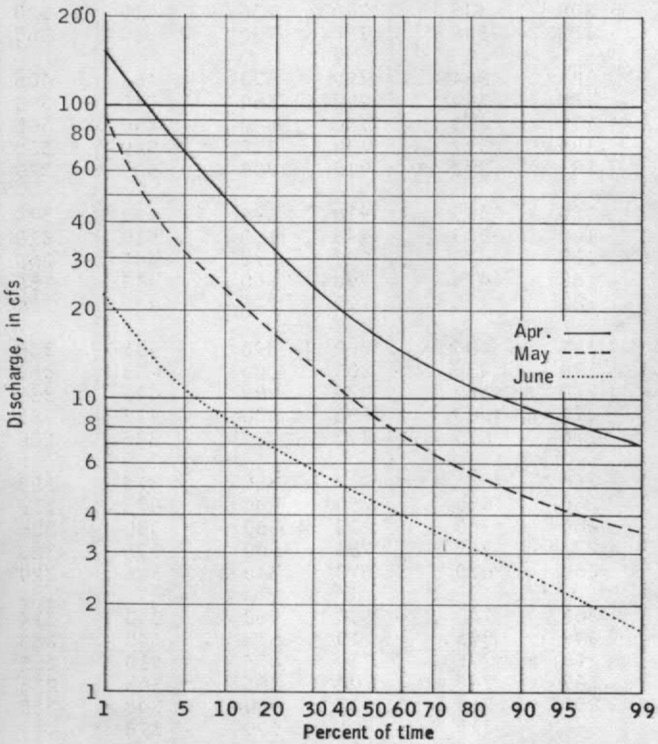


Figure 49c. FLOW-DURATION CURVES FOR APRIL, MAY, JUNE 1945-53.

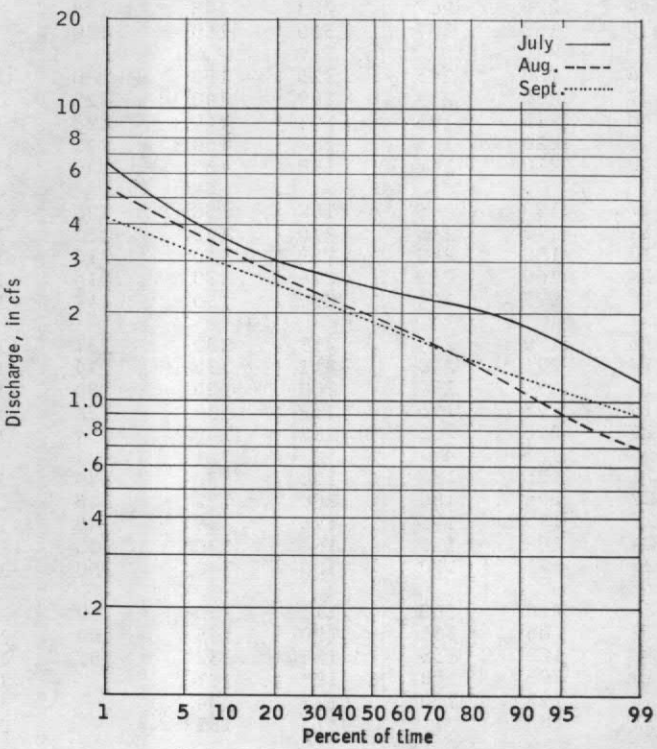


Figure 49d. FLOW-DURATION CURVES FOR JULY, AUGUST, SEPTEMBER 1945-53.

Table 6. Maximum - minimum daily discharge records, Nooksack River below Cascade Creek.

Maximum daily discharge of Nooksack River below Cascade Creek, near Glacier, for years 1947-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1,830	2,040	3,810	2,900	1,400	776	1,170	2,020	2,900	2,730	3,280	1,050
2	1,800	1,350	5,400	1,820	1,030	760	1,200	1,750	2,900	2,530	1,780	1,230
3	1,730	5,260	2,550	1,400	954	922	1,140	1,350	3,150	2,530	1,720	1,400
4	1,900	4,040	1,750	990	842	1,220	790	1,400	3,000	2,630	1,420	2,130
5	1,080	2,060	1,950	884	720	990	660	1,480	3,250	2,630	1,290	2,580
6	1,020	1,920	1,650	944	680	820	584	2,000	3,650	2,530	1,310	1,940
7	1,660	1,290	2,500	1,610	1,100	655	610	2,100	4,150	2,330	1,330	1,310
8	2,530	1,650	3,650	1,120	2,080	574	790	2,080	4,300	2,290	1,370	1,300
9	1,970	1,840	2,060	1,640	1,880	940	831	1,920	6,100	2,480	1,180	1,000
10	2,930	2,100	3,400	1,180	3,940	979	610	2,120	4,580	2,500	1,080	1,150
11	2,100	2,000	1,790	1,450	2,730	650	909	2,240	3,970	2,390	1,080	1,140
12	2,000	1,250	1,360	2,460	2,310	535	880	2,490	3,650	2,750	1,050	870
13	1,570	1,850	1,020	1,570	2,450	485	1,260	2,750	2,900	2,470	1,180	1,100
14	1,680	2,400	1,150	1,200	2,550	445	1,450	2,750	2,520	3,080	1,580	1,400
15	1,600	1,980	1,640	1,510	1,500	588	1,510	2,680	2,420	3,140	3,040	1,210
16	2,800	1,620	1,590	1,330	1,040	810	1,440	2,300	2,730	3,040	1,710	1,380
17	3,360	1,740	1,300	1,450	1,060	790	1,260	1,960	3,040	2,410	1,390	995
18	4,100	3,190	1,460	1,390	1,390	820	2,000	2,570	3,150	2,240	1,320	1,170
19	4,800	4,120	1,400	730	1,480	790	1,280	2,680	3,150	2,180	1,360	1,590
20	3,850	2,020	1,800	900	970	816	1,220	2,680	3,150	2,290	1,430	1,610
21	2,250	2,640	1,540	880	1,080	820	1,400	2,270	3,040	2,320	1,390	1,050
22	1,750	4,270	1,470	950	1,010	790	1,540	2,250	2,840	1,990	1,510	1,120
23	2,050	1,830	1,600	897	876	710	1,340	2,370	2,910	1,920	1,900	848
24	3,500	1,240	3,980	1,500	1,920	930	1,150	2,350	2,220	1,920	1,360	1,280
25	6,600	2,630	2,240	1,010	1,670	1,090	1,010	2,550	1,980	1,840	1,220	1,840
26	3,800	3,260	1,360	850	1,850	800	1,120	3,000	2,100	1,730	1,180	2,030
27	4,000	4,390	1,360	620	1,080	830	1,300	3,400	2,110	1,700	1,180	1,190
28	4,800	2,060	1,150	670	752	780	1,300	3,650	2,430	1,600	1,080	1,380
29	1,500	2,250	1,500	1,090	-	690	3,120	3,300	2,830	1,530	1,050	1,380
30	2,230	2,750	1,370	725	-	770	3,620	2,760	2,930	1,560	1,260	3,190
31	3,120	-	1,350	1,450	-	670	-	3,050	-	1,910	1,100	-

Minimum daily discharge of Nooksack River below Cascade Creek, near Glacier, for years 1947-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	215	234	150	160	128	150	210	261	792	620	420	400
2	198	209	155	151	125	148	208	255	820	700	360	390
3	190	198	190	125	125	148	203	286	760	650	430	340
4	220	267	283	145	125	145	200	305	760	730	430	320
5	198	317	306	160	120	142	188	336	750	730	380	365
6	180	243	226	150	128	142	180	354	790	670	460	405
7	220	214	209	140	123	142	180	389	924	660	510	390
8	215	193	201	140	128	146	179	433	750	680	490	405
9	220	185	188	150	125	143	180	392	730	710	520	365
10	210	245	188	160	139	136	180	392	910	705	505	379
11	180	245	188	150	125	129	180	505	910	695	490	344
12	170	245	276	140	112	131	180	505	948	710	510	310
13	150	250	259	140	110	131	168	475	831	670	440	255
14	160	243	276	130	114	129	168	475	790	660	415	255
15	175	234	230	130	114	129	182	475	790	725	410	330
16	170	214	219	130	131	131	192	480	760	690	435	330
17	201	206	211	130	134	131	190	485	805	680	485	350
18	196	198	208	130	130	131	210	560	970	600	490	335
19	193	196	219	130	132	141	276	680	935	630	425	285
20	210	203	219	140	134	146	276	675	790	710	385	270
21	175	188	208	130	145	170	280	675	760	660	375	323
22	204	180	200	130	145	172	286	650	750	600	375	313
23	195	175	176	130	145	174	286	760	820	560	380	306
24	188	170	164	130	145	170	273	760	750	600	375	323
25	171	170	180	140	150	172	264	670	670	540	325	320
26	210	165	173	150	150	169	261	760	680	560	340	314
27	206	165	180	145	150	174	249	805	710	615	340	283
28	188	155	185	137	151	181	246	775	730	605	310	255
29	195	150	183	137	-	188	249	740	708	585	308	238
30	192	150	173	134	-	185	255	740	637	580	308	255
31	283	-	173	131	-	212	-	715	-	500	396	-

Table 7. Maximum - minimum daily discharge records, Canyon Creek near Kulshan.

Maximum daily discharge of Canyon Creek at Kulshan, for years 1948-54

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	30	34	440	60	266	56	63	95	91	128	26	42
2	30	31	325	290	165	55	53	140	112	112	25	43
3	197	74	100	359	198	336	43	101	139	91	29	62
4	74	67	60	119	154	345	42	74	164	89	29	50
5	48	64	46	66	103	199	47	141	130	85	22	40
6	55	45	71	47	91	142	68	161	120	78	19.5	34
7	76	40	100	60	266	80	58	165	98	79	19	29
8	106	32	76	73	404	64	46	157	111	73	74	25
9	68	28	75	212	1,030	54	47	185	80	71	44	23
10	246	36	400	135	1,400	46	50	185	77	71	31	21
11	82	48	255	202	1,200	40	82	213	139	62	26	19.5
12	56	86	175	553	300	36	85	210	150	52	27	17.5
13	44	74	104	475	150	52	97	198	242	54	26	15.5
14	80	98	70	230	100	43	87	176	138	63	25	15
15	76	95	73	239	112	54	93	159	116	61	91	19.5
16	48	74	120	351	106	50	112	126	168	63	50	34
17	34	74	232	148	127	122	112	149	178	56	31	106
18	131	179	145	179	84	108	97	141	158	48	23	46
19	228	339	108	176	51	130	122	172	161	54	19.5	95
20	210	89	224	132	42	170	85	180	161	45	76	57
21	113	69	255	130	39	120	138	143	124	42	92	40
22	73	104	175	132	54	100	234	110	120	41	178	89
23	73	234	279	571	90	63	242	104	120	38	280	68
24	57	176	526	351	134	66	144	123	84	44	90	46
25	45	621	295	750	106	95	100	90	77	42	62	54
26	36	586	122	328	175	61	122	106	90	56	63	56
27	41	559	204	122	106	58	180	192	99	46	75	35
28	117	438	568	100	64	82	155	129	112	37	56	91
29	88	195	241	128	-	61	103	95	132	33	44	91
30	52	164	117	190	-	53	92	78	115	30	43	141
31	40	-	78	563	-	43	-	75	-	28	54	-

Minimum daily discharge of Canyon Creek at Kulshan, for years 1948-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	5.6	17	5.6	14	10	17.5	23	34	29	19.5	3.4	2.0
2	5.4	13	6.4	13.5	10	16.5	24	30	34	18	3.2	2.0
3	5.0	11	7.6	13	10	15.5	25	29	38	16.5	3.2	1.6
4	4.8	11.5	14	12.5	9.8	15	26	36	47	17	3.1	1.6
5	4.6	14	22	12	9.5	15	31	42	42	15.5	2.8	1.4
6	4.4	12.5	16.5	11.5	9.5	15.5	29	37	44	14	2.8	1.4
7	4.2	10.5	13.5	11	9.5	15.5	26	38	48	13	2.5	1.6
8	4.2	9.1	15	11	9	16.5	22	41	39	12	2.5	2.0
9	4.2	8.2	13	12	9	15.5	21	42	37	11	2.5	2.0
10	4.0	12	13	12	11	14	20	44	38	10	2.4	2.0
11	3.9	17.5	13.5	11	13	14	20	53	40	9	2.6	1.8
12	3.9	20	16	11	10	23	20	55	34	7.6	2.5	1.6
13	3.7	18	15	10.5	9.2	22	20	77	27	7.0	2.0	1.4
14	3.7	14.5	14.5	10.5	9.6	19.5	17.5	64	26	6.5	2.0	1.2
15	3.4	12	19	10.5	9.6	18	17	56	29	6.5	2.0	1.2
16	3.0	10.5	17.5	9.5	9.6	16.5	18.5	63	40	6.2	2.0	1.0
17	3.0	9.7	16.5	9.5	30	16.5	23	64	34	5.6	1.8	1.0
18	2.9	9.1	15.5	10.5	27	18	28	60	31	5.4	1.8	1.0
19	2.9	8.8	14	10	25	16	42	48	29	5.2	1.8	1.0
20	3.7	9.7	13	10.5	24	14.5	45	43	28	5.0	1.6	1.0
21	5.2	9.4	18	10.5	22	14	39	49	28	4.6	1.6	1.0
22	5.0	8.8	17.5	10	21	13.5	35	72	28	4.6	1.4	1.0
23	5.0	8.2	15.5	9.5	19	14.5	32	63	27	4.4	1.4	1.0
24	15	7.6	14	12.5	17.5	17	31	55	27	4.2	1.4	1.2
25	14	7.3	13	12.5	16	27	32	51	26	4.4	1.4	3.4
26	13	6.8	12	13	16	29	33	59	24	4.0	1.4	3.6
27	9.7	6.6	12	13	19.5	28	35	50	23	3.7	1.8	4.8
28	8.2	6.4	12	12	19.5	26	34	42	22	3.7	3.1	4.8
29	8.5	6.2	13	12	-	27	33	34	21	3.4	2.8	5.2
30	20	6.0	14.5	11	-	28	35	28	20	3.6	2.8	5.2
31	22	-	14	11	-	24	-	27	-	3.6	2.4	-

Table 8. Maximum - minimum daily discharge records, South Fork Nooksack River near Wickersham.

Maximum daily discharge of South Fork Nooksack River near Wickersham, for years 1934-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1,980	3,480	4,920	6,000	3,100	2,130	2,180	2,450	1,800	1,750	1,590	1,170
2	1,520	2,200	5,040	3,600	2,530	1,000	3,220	1,750	1,890	1,390	791	468
3	2,990	11,700	4,060	3,630	2,830	3,760	2,220	2,040	2,030	1,330	612	1,210
4	1,840	5,350	2,210	2,230	2,380	3,640	1,390	2,440	1,930	1,330	534	1,500
5	1,750	6,360	3,060	2,000	1,580	2,170	1,610	2,960	1,800	1,280	507	2,560
6	842	3,200	3,590	2,520	3,150	1,760	1,100	3,430	2,090	1,280	512	1,850
7	1,500	2,120	3,710	6,980	4,380	1,640	1,020	2,050	2,330	1,300	490	1,160
8	1,960	3,460	3,330	2,660	4,490	1,540	1,380	2,020	2,760	1,100	814	1,470
9	2,620	2,320	4,460	1,850	8,680	2,840	3,890	2,310	3,520	1,160	420	1,780
10	4,560	1,900	5,710	1,710	12,700	1,960	2,030	2,310	3,020	1,470	358	1,010
11	2,820	2,560	5,890	2,800	6,140	1,300	2,300	2,960	2,730	1,450	417	945
12	2,530	4,540	2,640	4,670	2,440	1,260	1,800	2,670	2,300	1,070	436	1,640
13	1,470	2,880	2,560	3,450	3,940	1,990	1,990	2,490	1,930	1,310	359	1,490
14	2,060	4,970	2,390	3,260	6,340	1,520	2,380	2,430	3,300	1,430	362	2,390
15	4,120	2,820	3,430	3,220	3,100	1,300	2,000	2,310	3,230	1,350	1,890	1,170
16	3,390	2,160	2,420	4,490	2,160	2,160	2,040	2,240	2,110	2,070	642	2,100
17	4,230	2,050	3,140	3,410	2,200	1,810	3,570	2,720	2,170	1,340	410	1,780
18	3,960	5,480	2,660	3,660	2,610	1,380	4,270	2,430	2,940	833	344	1,120
19	5,400	5,540	2,020	2,350	2,040	1,380	3,170	2,390	2,280	833	465	1,240
20	5,860	3,770	4,600	1,760	2,520	3,000	1,700	2,240	3,430	680	551	2,720
21	2,280	2,060	3,050	1,680	2,810	2,190	2,090	1,750	4,870	704	850	1,160
22	1,480	2,540	4,530	2,000	2,140	1,520	1,900	2,530	2,420	722	1,610	945
23	1,560	4,140	3,040	4,240	2,020	1,400	1,800	1,970	2,300	722	1,580	620
24	6,290	2,250	5,740	8,240	3,000	1,820	1,650	1,900	2,060	680	680	1,220
25	11,600	4,520	2,960	8,550	2,630	1,850	1,440	2,330	1,640	674	627	1,630
26	5,570	4,230	2,320	5,260	2,990	2,000	1,410	2,640	1,810	890	471	1,720
27	2,760	7,450	2,420	2,830	2,300	2,850	1,980	2,580	1,470	686	613	1,040
28	6,350	2,680	5,880	2,290	1,900	2,360	2,320	2,850	1,540	661	413	2,030
29	2,590	2,020	6,060	1,990	-	1,440	8,900	2,280	1,760	1,320	349	1,290
30	2,340	2,840	3,880	3,270	-	2,320	6,060	1,850	1,640	904	584	2,360
31	5,900	-	4,480	5,310	-	1,910	-	1,860	-	896	696	

Minimum daily discharge of South Fork Nooksack River near Wickersham, for years 1934-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	80	95	93	256	140	212	274	390	498	156	89	79
2	77	93	91	249	145	209	266	363	413	153	89	76
3	74	93	93	232	145	209	254	430	372	147	90	75
4	78	95	93	270	145	206	243	450	342	145	102	73
5	82	120	110	270	150	206	239	446	342	134	86	73
6	75	120	368	235	145	197	235	501	335	129	84	71
7	70	105	347	220	140	190	232	559	415	127	85	70
8	69	98	390	215	95	236	232	446	376	124	83	68
9	77	95	345	210	120	274	240	394	329	122	82	74
10	88	93	335	200	135	262	256	390	355	119	80	67
11	87	107	311	200	165	273	327	472	338	117	80	66
12	86	115	315	195	180	270	382	446	368	114	81	66
13	86	107	288	190	188	263	363	422	329	119	79	76
14	85	100	274	185	165	248	372	432	282	122	77	82
15	84	98	260	175	175	245	387	390	260	112	77	78
16	84	98	249	170	170	250	445	481	228	110	77	77
17	82	172	239	165	150	240	404	471	230	110	75	77
18	80	159	226	160	160	236	368	435	248	107	75	80
19	80	154	219	155	170	230	350	573	216	100	73	78
20	86	186	206	150	180	222	359	523	206	100	71	74
21	90	156	200	150	186	232	386	501	212	100	71	72
22	91	137	203	145	176	249	408	519	200	98	70	70
23	88	123	242	145	224	307	413	525	194	94	72	69
24	92	115	230	140	231	295	390	574	203	94	72	67
25	90	112	220	140	219	269	404	491	203	94	72	67
26	97	105	220	140	216	261	432	390	190	100	70	67
27	104	103	212	135	212	288	410	340	175	99	70	73
28	94	98	216	135	216	348	368	347	164	97	76	73
29	103	95	229	135	-	318	385	381	161	97	79	72
30	103	93	222	135	-	298	410	404	158	93	76	74
31	100	-	239	135	-	286	-	494	-	91	76	-

Table 9. Maximum - minimum daily discharge records, Skookum Creek near Wickersham.

Maximum daily discharge of Skookum Creek near Wickersham, for years 1948-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	391	592	1,210	317	444	302	634	328	268	324	275	97
2	252	290	1,020	382	304	170	368	290	296	221	150	127
3	487	956	400	460	392	800	220	220	352	264	112	212
4	291	450	300	195	325	900	182	258	358	212	98	199
5	239	343	280	511	226	550	258	391	283	207	92	510
6	164	346	296	464	246	400	235	373	299	197	91	311
7	238	233	228	403	469	314	168	343	318	212	91	182
8	372	212	207	269	579	308	240	414	517	191	168	234
9	257	440	567	471	1,280	468	494	434	562	179	94	127
10	597	354	474	413	1,690	296	296	434	542	264	74	94
11	287	420	408	467	862	181	235	508	464	183	74	99
12	306	525	434	593	400	154	260	476	397	195	85	67
13	246	298	296	467	346	136	307	448	318	224	77	69
14	274	454	271	290	218	136	282	434	248	236	69	84
15	486	325	409	438	750	184	259	394	285	219	294	218
16	387	403	430	586	400	166	349	323	400	202	97	390
17	718	442	394	436	301	400	304	411	385	157	69	264
18	411	780	490	304	526	350	282	445	361	142	57	179
19	480	1,010	411	331	366	381	285	480	385	160	66	171
20	840	419	620	260	349	486	335	380	352	119	138	193
21	401	407	450	203	560	360	405	294	340	122	285	110
22	280	491	408	290	519	246	362	329	329	121	416	248
23	214	422	445	600	394	245	329	329	338	138	351	122
24	260	355	730	450	434	178	271	259	243	121	177	252
25	549	403	460	890	401	172	260	253	209	113	134	269
26	350	883	311	500	582	142	274	285	269	164	117	235
27	264	1,260	440	250	350	145	388	478	269	118	122	212
28	282	582	1,020	362	260	187	378	263	296	121	93	274
29	368	385	495	276	-	268	928	300	279	181	82	225
30	387	521	329	527	-	242	660	341	285	144	141	574
31	682	-	371	755	-	328	-	323	-	162	157	-

Minimum daily discharge of Skookum Creek near Wickersham, for years 1948-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	23	35	22	38	24	46	46	60	91	44	26	23
2	22	26	24	34	23	44	46	63	101	42	25	22
3	22	24	33	28	23	41	73	69	96	42	26	21
4	21	26	84	30	22	39	67	88	96	45	24	20
5	21	31	70	31	22	41	62	100	102	46	23	19
6	21	25	61	33	23	40	58	102	105	48	22	18.5
7	20	23	59	34	23	38	59	96	90	45	23	17.5
8	20	22	71	37	22	46	58	91	80	44	23	17.5
9	20	21	50	40	19	45	56	96	82	42	22	19
10	20	45	50	38	32	44	55	111	78	40	20	20
11	20	66	51	35	26	41	58	106	72	39	21	20
12	19	61	72	33	23	38	58	84	68	39	21	18.5
13	19	53	67	32	23	36	57	74	68	37	20	19.5
14	18.5	42	67	32	24	36	55	83	64	35	20	19
15	18.5	37	68	30	23	37	56	116	65	33	20	19
16	18	30	63	29	62	41	67	128	73	33	20	19
17	18	28	58	28	41	41	84	126	83	33	19	19
18	18	27	57	29	40	41	85	139	83	32	19	18.5
19	18	28	49	29	37	38	81	121	82	32	19	18.5
20	20	31	51	35	36	37	79	118	78	32	18.5	18
21	23	27	50	29	40	43	85	144	77	31	18.5	17.5
22	19	26	53	28	38	43	84	155	70	31	18.5	17.5
23	19	25	44	28	37	47	78	136	72	30	19	17
24	40	24	40	30	38	44	82	128	65	30	18.5	20
25	28	23	36	31	47	42	74	121	57	29	18.5	23
26	23	22	35	32	41	41	73	123	54	29	18.5	24
27	21	21	34	30	42	46	68	111	70	29	20	22
28	19.5	20	39	28	46	47	64	99	64	28	20	25
29	24	19.5	46	27	-	45	64	88	54	28	24	24
30	50	21	42	26	-	44	63	84	49	27	20	23
31	43	-	41	25	-	43	-	80	-	26	26	-

Table 10. Maximum - minimum daily discharge records, Nooksack River near Lynden.

Maximum daily discharge of Nooksack River near Lynden, for years 1944-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	11,000	16,500	9,120	10,000	16,500	9,180	15,000	14,600	9,000	7,930	8,450	3,250
2	6,350	10,600	23,800	10,600	10,000	6,000	14,800	9,110	7,750	7,990	6,080	2,780
3	8,630	24,100	13,500	11,700	9,140	6,460	7,830	8,700	8,700	6,820	4,290	5,520
4	7,950	31,400	7,570	6,340	9,050	20,100	6,050	8,700	8,480	7,180	3,810	4,520
5	5,040	14,000	8,860	6,810	7,080	11,700	5,180	7,570	9,790	7,000	3,420	11,300
6	3,900	9,370	11,800	11,600	6,020	10,800	4,870	8,800	8,700	7,290	3,400	10,100
7	5,920	6,450	6,770	17,300	9,470	7,740	4,080	7,970	10,400	6,830	3,690	5,590
8	6,040	6,610	5,150	16,300	17,600	6,120	4,050	7,880	10,800	6,870	3,760	7,880
9	5,450	6,020	12,600	8,560	27,700	7,720	8,620	9,080	14,900	6,460	3,130	4,870
10	12,900	13,000	13,700	7,860	39,000	8,180	9,040	9,840	16,200	6,540	2,890	3,880
11	10,200	7,700	22,300	7,410	34,600	5,250	5,670	10,400	13,200	7,380	3,010	2,970
12	7,650	18,800	11,500	14,100	18,800	4,030	7,390	11,000	12,200	6,010	3,130	2,730
13	8,960	9,620	7,630	13,200	10,200	3,510	7,030	11,200	10,100	7,020	2,780	2,610
14	5,140	11,500	6,820	10,200	16,000	3,500	5,200	10,600	7,550	7,970	2,780	2,680
15	8,710	12,000	6,080	7,390	12,900	3,900	5,540	10,200	7,000	8,530	7,000	2,900
16	13,600	7,940	5,300	10,900	9,970	5,000	5,950	9,270	9,100	8,150	5,210	6,000
17	11,700	6,580	9,450	16,000	12,700	6,640	7,740	7,680	10,800	7,180	3,390	6,600
18	16,400	13,700	8,320	7,940	6,510	7,180	6,200	9,160	10,300	5,850	2,810	3,800
19	21,300	20,000	7,070	6,900	6,770	8,200	7,560	9,910	10,600	5,250	2,860	5,700
20	20,000	14,500	15,100	7,200	8,400	10,400	7,390	9,870	10,600	5,220	3,810	4,600
21	13,400	12,100	12,000	7,000	10,000	8,000	7,560	8,200	9,710	5,150	4,250	3,640
22	8,330	20,700	8,900	7,600	11,500	6,340	8,140	8,600	9,250	4,830	5,360	4,110
23	7,600	12,500	9,300	12,100	10,000	4,600	6,970	8,140	9,340	4,970	10,300	4,020
24	7,370	11,200	17,800	18,900	9,050	4,020	7,030	8,300	8,060	5,050	5,740	2,940
25	38,700	11,700	23,900	17,600	11,600	4,260	5,520	8,800	6,390	4,580	4,160	9,270
26	38,100	18,800	10,100	17,800	11,900	4,590	6,680	10,600	6,510	4,300	3,630	6,420
27	13,700	30,900	8,120	7,360	9,560	6,340	6,180	11,600	8,510	4,320	4,160	5,300
28	7,750	15,800	23,600	6,250	6,680	4,880	7,600	12,200	7,160	3,900	3,500	5,540
29	5,680	9,180	18,400	6,400	-	4,800	17,200	10,600	8,500	4,440	3,010	4,200
30	8,010	10,300	9,120	8,060	-	4,830	31,700	8,700	8,700	5,000	3,500	7,250
31	20,400	-	6,120	12,800	-	6,040	-	9,130	-	4,650	4,300	-

Minimum daily discharge of Nooksack River near Lynden, for years 1944-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1,040	1,230	625	890	900	1,660	1,620	1,860	2,700	1,900	1,570	1,100
2	1,050	1,030	630	850	880	1,620	1,630	1,830	2,860	1,920	1,490	1,130
3	1,020	908	678	830	860	1,530	1,880	1,830	3,270	2,140	1,490	1,160
4	980	926	945	810	860	1,410	1,780	2,000	3,420	2,110	1,420	1,020
5	976	1,080	1,770	850	850	1,380	1,640	2,300	3,420	2,300	1,300	1,120
6	928	984	1,610	1,000	850	1,400	1,590	2,500	3,760	2,500	1,470	1,010
7	938	900	1,310	900	850	1,380	1,570	2,660	3,630	2,320	1,560	1,170
8	962	816	1,500	900	850	1,410	1,600	2,760	3,390	2,100	1,520	1,300
9	944	772	1,400	1,000	880	1,500	1,720	2,990	3,390	2,300	1,410	1,280
10	902	780	1,260	1,100	1,340	1,450	1,720	2,660	3,510	2,360	1,420	1,230
11	908	1,080	1,200	1,000	1,400	1,400	1,710	3,500	3,280	2,410	1,340	1,130
12	890	1,340	1,940	900	1,200	1,480	1,680	3,340	3,060	2,400	1,340	1,040
13	848	1,300	2,110	860	1,180	1,440	1,640	2,770	2,840	2,150	1,370	1,010
14	778	1,240	2,030	840	1,150	1,400	1,600	2,670	2,660	1,940	1,410	1,070
15	739	1,130	1,920	800	1,100	1,360	1,760	3,010	2,880	1,940	1,410	1,050
16	712	1,020	1,880	760	1,340	1,360	1,850	3,010	3,130	2,100	1,410	1,050
17	706	926	1,790	740	1,320	1,410	2,000	3,010	3,340	2,320	1,380	1,050
18	706	866	1,660	760	1,390	1,460	2,150	2,780	3,440	2,160	1,340	1,070
19	739	838	1,580	760	1,370	1,430	2,310	3,630	3,520	2,160	1,240	1,160
20	728	849	1,450	880	1,310	1,390	2,230	3,760	3,170	2,070	1,180	1,100
21	849	866	1,390	800	1,240	1,430	2,290	3,630	2,900	2,000	1,150	900
22	783	800	1,420	740	1,260	1,380	2,440	3,630	2,660	2,130	1,120	950
23	750	756	1,310	720	1,390	1,400	2,500	3,700	2,650	2,020	1,120	952
24	1,380	739	1,220	1,000	1,410	1,710	2,350	3,430	2,990	1,890	1,150	925
25	1,340	706	1,140	1,000	1,490	1,510	2,140	3,190	2,590	1,840	1,180	1,070
26	956	684	1,070	1,050	1,480	1,470	2,040	3,270	2,920	1,720	1,160	1,060
27	810	656	1,050	1,100	1,450	1,470	1,940	3,900	3,010	1,640	1,200	980
28	756	635	1,050	970	1,490	1,650	1,820	3,390	3,130	1,940	1,200	1,100
29	750	615	1,150	950	-	1,610	1,780	3,150	2,460	2,010	1,200	1,080
30	1,350	605	1,200	930	-	1,600	1,780	2,810	2,110	1,730	1,150	1,150
31	1,710	-	1,000	900	-	1,570	-	2,600	-	1,570	1,100	-

Table 11. Maximum - minimum daily discharge records, Fishtrap Creek at Lynden.

Maximum daily discharge of Fishtrap Creek at Lynden, for years 1948-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	18.5	107	139	164	207	132	150	136	44	19	13	8.4
2	14.5	80	115	154	153	93	146	87	195	20	11	8.2
3	13	195	102	200	145	142	112	73	30	15	9.8	9.6
4	13	214	86	126	150	217	95	97	27	14.5	8.9	9.9
5	13.5	113	190	109	121	217	80	125	30	14.5	8.4	8.4
6	14.5	66	136	176	110	223	80	80	24	15.5	8.1	10.5
7	19	50	139	240	151	160	70	61	25	14.5	7.9	10
8	25	47	104	194	213	118	62	52	22	13.5	9.4	13.5
9	17	54	252	140	417	188	108	50	38	12	8.6	10.5
10	29	74	278	104	533	145	127	46	44	13	8.1	8.6
11	39	89	184	85	499	102	72	56	34	12.5	7.6	7.8
12	38	62	226	106	302	125	96	80	30	12	7.1	7.6
13	26	55	127	129	211	180	115	55	27	11.5	7.1	7.4
14	20	44	106	126	212	154	96	41	31	10.5	7.1	7.3
15	16.5	61	164	140	235	206	102	45	22	13.5	13.5	7.4
16	19	67	162	170	282	216	130	43	21	12	11.5	11.5
17	13	67	151	115	246	159	134	42	19.5	10.5	8.8	12
18	39	121	145	94	164	160	102	48	18.5	10	8.1	9.8
19	39	179	127	100	130	212	82	50	17	10	7.9	9.8
20	82	125	233	89	194	160	72	46	23	9.8	11.5	17
21	80	121	151	79	159	174	64	50	19	9.5	16.0	18
22	46	298	155	97	169	169	72	48	17	9.5	14.0	12
23	60	170	138	208	164	126	87	41	21	9.2	15.5	11
24	61	115	241	327	174	104	75	37	25	8.9	15.5	17
25	51	145	257	390	184	92	70	34	22	8.7	14.5	30
26	34	157	149	348	212	85	64	32	19	8.9	11.5	21
27	35	152	167	158	160	102	64	32	16.5	9.5	13	17
28	44	96	300	116	115	96	62	29	17	9.0	11.5	14
29	46	94	250	154	-	134	132	30	17	11.5	9.9	21
30	102	121	150	144	-	109	235	53	16.5	11	9.0	17
31	153	-	159	202	-	118	-	74	-	10.5	8.7	-

Minimum daily discharge of Fishtrap Creek at Lynden, for years 1948-59

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	3.0	5.0	3.4	17.5	13	28	23	21	10.5	6.0	3.1	1.3
2	3.0	4.8	4.2	20	14	27	24	21	10.5	6.0	3.0	1.2
3	2.8	5.0	5.0	17	14	26	24	20	10	5.8	3.1	1.0
4	3.2	5.0	9.7	18	14	30	24	19	9.2	5.8	3.0	1.0
5	3.2	4.8	12	20	14.5	29	22	18	8.9	5.6	2.8	0.9
6	3.1	4.5	10.5	22	15	29	21	17.5	8.6	5.1	3.8	1.0
7	3.3	4.5	9.4	20	15	28	20	16	8.9	5.0	3.3	1.0
8	3.4	4.6	14	21	15	25	21	15.5	8.6	4.6	3.0	1.0
9	4.0	4.6	17.5	21	15.5	27	21	14	8.3	4.4	2.8	1.0
10	4.1	5.2	16	28	30	28	20	13.5	8.0	4.1	3.0	0.8
11	4.3	5.6	14	30	28	34	19	13.5	8.0	4.0	2.7	0.9
12	4.3	6.0	14	25	23	35	18	13	8.0	3.7	2.6	1.2
13	4.3	5.6	14	23	21	34	18.5	13.5	8.0	4.4	2.5	0.9
14	3.8	5.4	13.5	22	19	32	22	14.5	7.8	4.1	2.4	1.6
15	3.6	5.0	13.5	21	21	32	21	13	7.5	4.1	2.4	2.4
16	3.6	4.8	13	20	37	32	19	13	7.5	3.8	2.3	3.8
17	3.6	4.6	13	23	35	32	18	12	7.2	3.7	2.4	3.8
18	3.6	4.4	13	25	35	34	17	12	7.0	3.7	2.3	3.7
19	3.6	4.4	12	24	35	31	16.5	12	7.0	3.7	2.1	3.7
20	3.8	4.2	10.5	23	33	28	16	12.5	6.5	4.0	2.2	3.9
21	4.0	4.0	15	23	31	26	15.5	11.5	6.2	3.8	2.1	3.7
22	3.6	4.0	21	20	30	25	15	11.5	6.2	3.7	2.0	3.7
23	3.6	4.0	19.5	18	28	28	14.5	11	6.2	3.3	2.0	3.4
24	3.8	4.1	15	17	28	34	13.5	10.5	6.2	3.4	2.0	3.5
25	3.8	3.8	13	16	36	32	13	10	6.2	3.2	1.8	3.0
26	4.0	3.6	11	15	38	32	14	9.8	6.5	3.3	1.8	2.8
27	4.6	3.6	10	14	36	33	23	9.5	6.5	3.4	1.6	2.6
28	4.6	3.6	10	14	32	31	22	9.8	6.2	3.4	1.6	2.8
29	5.0	3.4	16	13	-	31	21	10.5	6.2	3.2	2.0	2.8
30	5.6	3.4	25	13	-	30	20	10.5	6.2	3.3	1.3	3.0
31	5.8	-	22	13	-	28	-	10.5	-	3.2	1.6	-

Table 12. Maximum - minimum daily discharge records, Dakota Creek near Blaine.

Maximum daily discharge of Dakota Creek near Blaine, for years 1948-54

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	4.2	9.2	220	59	186	70	192	22	9.6	9.9	2.8	3.9
2	3.9	8.4	281	218	120	83	128	107	8.8	12.5	3.0	3.6
3	4.4	20	100	262	142	244	77	57	8.4	8.9	2.8	4.1
4	7.2	24	90	100	189	295	52	27	8.1	6.6	2.8	4.1
5	6.8	18.5	58	61	106	368	40	30	7.4	5.3	2.6	3.9
6	6.2	14.5	41	50	123	328	38	26	6.8	4.5	3.3	4.6
7	18.5	13	108	80	210	156	32	22	9.2	3.6	3.3	7.0
8	13	11.5	136	201	230	104	28	20	8.4	4.4	3.1	3.2
9	9.2	10.5	77	228	587	108	25	17.5	7.2	6.2	2.7	3.1
10	24	11	127	130	717	180	24	17.5	7.2	5.2	3.1	2.8
11	73	16.5	159	148	521	134	26	62	7.2	4.9	2.7	2.8
12	33	30	192	159	223	68	100	84	8.4	3.7	2.7	2.8
13	18	45	164	158	519	173	80	38	18.5	3.3	2.6	2.6
14	13.5	173	108	79	228	230	49	25	20	3.3	2.9	3.1
15	10.5	210	75	218	240	474	72	20	14	4.8	6.8	3.7
16	8.4	182	83	169	220	344	120	17.5	11	3.3	4.9	5.7
17	7.4	156	124	112	190	303	108	16.5	8.7	3.1	3.3	4.9
18	7.2	90	95	88	115	300	55	21	7.9	3.1	3.3	4.1
19	7.4	140	129	163	86	345	40	26	7.5	3.3	3.1	4.5
20	9.2	128	100	360	121	156	34	25	9.9	3.3	3.2	3.7
21	6.8	80	97	380	135	148	26	28	8.9	3.1	11.0	3.1
22	6.2	152	141	200	298	128	42	24	6.6	4.6	6.4	4.8
23	7.4	280	233	307	144	94	67	18.5	8.9	5.9	6.2	4.8
24	7.8	500	388	249	210	76	58	15	11.5	3.3	6.7	5.1
25	16.5	250	345	601	242	63	40	13	10.5	7.8	5.9	4.1
26	16	130	116	386	325	51	40	12	8.7	3.1	5.9	3.9
27	11	215	444	148	144	97	46	12	7.5	5.9	5.3	4.8
28	9.2	220	574	112	100	98	73	11	7.2	4.3	5.1	4.8
29	8.1	170	269	113	-	55	38	12	8.8	3.7	4.3	4.6
30	7.8	150	124	201	-	47	28	10.5	6.5	3.4	4.1	4.6
31	8.1	-	83	260	-	44	-	10	-	3.2	4.6	-

Minimum daily discharge of Dakota Creek near Blaine, for years 1948-54

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	1.8	2.2	1.9	10.5	6.2	17.5	20	11.5	3.5	2	0.7	1.2
2	1.8	2.1	3.5	13	6.2	16	21	9.6	3.1	2	0.8	1.3
3	1.6	2.2	3.7	15	6.2	15	19.5	8.4	2.7	2	0.8	1.2
4	1.6	2.2	6.2	16	6.1	14.5	18.5	7.8	3.2	2	0.7	1.0
5	1.8	1.8	6.8	17	6.2	13.5	17	8.4	3.3	2	0.7	1.0
6	1.5	1.3	5.9	23	6.2	13	16	8.1	3.3	1.9	0.9	1.2
7	1.5	1.5	5.4	26	6.1	12	15	7.2	3.3	1.9	1.0	1.6
8	1.4	1.4	7.2	32	6	11.5	14	6.8	3.3	1.9	1.2	1.2
9	1.6	1.3	8.1	27	6	11	12	6.5	2.9	1.9	1.0	1.3
10	1.9	1.3	7.4	23	45	12	11	5.9	2.4	1.8	1.0	1.2
11	1.9	1.8	5.9	14	20	11.5	10.5	6.2	2.6	1.7	1.3	1.0
12	1.8	2.4	12	12	18	11.5	10	5.6	3.1	1.6	1.0	1.0
13	1.6	1.9	9.2	9.6	19	17.5	11.5	6.2	2.6	1.5	0.9	1.0
14	1.4	1.6	7.4	9.6	20	13	11	5.9	1.8	1.5	1.2	1.0
15	1.4	1.3	6.2	8.8	30	13	10.5	5.4	1.4	1.5	1.2	1.0
16	1.4	1.0	5.6	8.8	35	24	10	5.2	3.1	1.5	1.4	1.0
17	1.8	1.4	5.2	8.4	30	25	10	4.9	2.4	1.5	1.3	1.0
18	1.4	1.0	4.9	7.8	26	26	9.6	4.6	2.8	1.5	1.5	1.0
19	1.4	1.9	4.6	7.5	24	23	8.8	4.6	2.9	1.5	1.4	0.9
20	1.4	1.4	4.2	8	22	20	8.4	5.6	3.1	1.5	1.4	0.8
21	2.2	1.3	5.6	8.7	21	18	8.4	5.4	2.9	1.5	1.4	1.0
22	1.9	1.3	8.8	8	20	17	7.8	4.9	2.9	1.5	1.3	0.6
23	1.9	1.0	7.2	7.5	19	20	7.2	4.6	2.6	1.5	1.3	0.7
24	2.1	1.3	5.6	7	19	26	6.8	4.4	2.5	1.5	1.2	0.9
25	2.1	1.8	4.6	7	18.5	31	6.5	4.4	2.4	1.5	1.4	1.2
26	1.9	1.5	3.7	7.5	18.5	28	6.5	4.4	1.9	1.5	1.5	1.0
27	1.9	1.5	3.3	7.2	20	24	7.2	4.4	2.2	1.5	1.5	1.0
28	1.6	1.4	3.5	7	18.5	19.5	13.5	4.2	2.1	1.4	1.4	1.4
29	2.1	1.2	8.8	6.8	-	22	10.5	4.2	2.0	1.0	1.0	1.8
30	2.1	1.5	16.5	6.6	-	24	10.5	3.9	2.0	1.0	1.6	2.1
31	1.8	-	13	6.4	-	24	-	3.5	-	0.8	1.0	-

Table 13. Maximum, minimum, and average of the monthly discharges, in acre-feet, for the period 1938-59. Nooksack River below Cascade Creek.

	October	November	December	January	February	March	April	May	June	July	August	September
Maximum	74,980	92,420	83,240	50,840	43,960	34,990	51,420	98,650	156,300	120,200	77,510	57,190
Minimum	16,910	12,880	15,830	10,940	9,510	11,710	18,560	46,980	53,150	44,570	29,090	24,860
Average	43,300	40,300	39,660	24,050	22,300	20,300	32,560	72,600	89,110	78,700	45,600	34,760

Table 14. Discharge, in cubic feet per second, equaled or exceeded for specified percent of time--1938-59. Nooksack River below Cascade Creek.

	Percent of time												
	1	5	10	20	30	40	50	60	70	80	90	95	99
October	3,600	1,900	1,400	950	700	580	480	400	340	290	240	215	180
November	3,200	1,700	1,250	900	720	600	520	450	390	330	270	230	180
December	2,700	1,500	1,150	850	680	580	500	430	370	310	250	220	180
January	1,550	980	780	580	480	410	360	310	270	230	190	165	135
February	1,800	1,000	740	520	410	340	290	250	220	190	165	145	125
March	1,000	660	540	420	360	310	280	250	220	200	180	160	140
April	1,600	1,100	920	740	620	540	480	420	370	320	260	230	180
May	2,900	2,300	2,000	1,600	1,400	1,200	1,100	960	840	700	560	450	330
June	3,700	2,600	2,200	1,800	1,600	1,450	1,350	1,250	1,150	1,050	920	840	720
July	2,700	2,200	1,950	1,650	1,450	1,300	1,150	1,020	920	820	720	660	580
August	1,700	1,300	1,100	940	830	750	700	630	580	520	450	410	350
September	1,700	1,100	900	700	610	550	500	460	430	390	350	320	270
Period	2,800	1,850	1,500	1,120	880	700	580	480	390	320	240	200	150

Table 15. Maximum, minimum, and average of the monthly discharges, in acre-feet, for the period 1949-53. Canyon Creek at Kulshan.

	October	November	December	January	February	March	April	May	June	July	August	September
Maximum	3,720	6,110	9,140	13,020	10,830	4,710	4,110	6,760	6,910	3,150	1,290	1,210
Minimum	474	638	1,540	1,230	1,870	1,460	2,630	4,030	2,020	510	139	197
Average	2,330	3,510	3,920	4,610	4,500	2,690	3,550	5,260	4,090	1,940	720	779

Table 16. Discharge, in cubic feet per second, equaled or exceeded for specified percent of time--1949-53. Canyon Creek at Kulshan.

	Percent of time												
	1	5	10	20	30	40	50	60	70	80	90	95	99
October	260	102	72	52	42	35	28	23	17.5	10	5.0	3.8	3.0
November	660	180	102	64	47	37	31	26	22	19	16	14.3	12
December	580	270	165	82	51	36	28	23	19.5	16	12	10	7.2
January	640	320	190	100	58	38	28	22	18.5	15.5	12.5	11	9.3
February	900	240	140	87	64	49	39	30	24	17.5	12.5	10.5	8.5
March	260	106	75	54	44	38	33	28	25	21	17	15	12
April	215	133	105	80	66	56	49	43	37	32	27	23	18.5
May	190	150	125	98	80	68	58	50	43	36	30	26	21
June	210	170	145	120	100	86	74	65	57	49	41	36	30
July	95	70	60	50	42	36	30	23	16.5	11	6.4	4.5	3.4
August	88	33	23	16	12.5	10.2	8.8	7.4	5.8	4.1	2.4	1.8	1.3
September	115	46	25	14.5	11	9.0	7.5	6.5	5.2	3.6	1.7	1.2	0.9
Period	360	150	105	74	55	42	33	25	18	12.5	7.0	4.3	1.5

Table 17. Maximum, minimum, and average of the monthly discharges, in acre-feet, for the period 1934-59. South Fork Nooksack River near Wickersham.

	October	November	December	January	February	March	April	May	June	July	August	September
Maximum	82,200	98,780	135,300	128,600	102,600	72,980	86,640	102,500	103,500	58,370	30,790	47,060
Minimum	7,460	7,520	30,740	11,910	16,590	19,910	26,940	39,830	18,340	7,570	5,010	4,840
Average	42,280	54,060	66,850	56,480	42,640	40,540	51,360	67,270	53,740	26,480	11,660	16,320

Table 18. Discharge, in cubic feet per second, equaled or exceeded for specified percent of time--1953-59. South Fork Nooksack River near Wickersham.

	Percent of time												
	1	5	10	20	30	40	50	60	70	80	90	95	99
October	4,700	2,250	1,550	970	680	500	360	265	185	125	102	94	80
November	4,700	2,500	1,800	1,250	950	770	630	520	420	330	220	140	90
December	4,600	2,750	2,050	1,420	1,100	880	740	610	510	420	330	270	200
January	5,000	2,500	1,750	1,200	900	720	600	490	405	330	255	210	150
February	4,000	1,950	1,400	990	770	625	520	430	355	285	220	185	140
March	2,400	1,500	1,150	860	700	600	520	450	400	345	290	260	220
April	2,800	1,650	1,400	1,100	960	840	750	660	580	500	410	350	265
May	2,600	2,050	1,750	1,450	1,250	1,100	1,000	900	800	700	580	500	390
June	2,800	2,000	1,650	1,300	1,100	950	810	700	580	470	360	290	200
July	1,350	1,020	850	650	520	420	340	270	220	175	130	115	95
August	800	435	325	240	200	170	150	130	115	102	88	80	70
September	1,900	980	560	320	230	180	150	130	115	100	86	78	70
Period	3,500	1,900	1,470	1,050	840	670	540	430	320	220	135	105	80

Table 19. Maximum, minimum, and average of the monthly discharges, in acre-feet, for the period 1949-59. Skookum Creek near Wickersham.

	October	November	December	January	February	March	April	May	June	July	August	September
Maximum	13,360	16,290	17,050	19,390	16,020	13,550	13,220	16,280	17,040	10,400	5,940	8,240
Minimum	1,530	1,890	4,930	2,710	2,850	3,430	7,290	7,960	4,650	2,180	1,300	1,710
Average	7,530	10,020	10,960	9,110	8,530	7,090	9,510	12,300	10,140	5,980	3,220	3,540

Table 20. Discharge, in cubic feet per second, equaled or exceeded for specified percent of time--1949-59. Skookum Creek near Wickersham.

	Percent of time												
	1	5	10	20	30	40	50	60	70	80	90	95	99
October	620	370	270	170	130	100	84	69	54	39	26	21	17
November	800	420	340	250	195	155	125	100	80	60	40	29	21
December	950	440	350	260	205	165	135	115	95	75	58	47	33
January	640	420	310	220	170	140	110	90	71	54	39	32	26
February	850	420	310	220	170	130	100	82	65	52	40	34	27
March	540	270	200	150	125	110	95	82	70	57	48	43	38
April	500	310	255	210	180	160	140	125	105	90	74	64	53
May	480	360	310	260	230	205	185	165	150	130	110	95	70
June	540	340	280	230	195	170	150	130	115	98	81	72	58
July	260	195	170	140	120	105	91	78	65	52	40	34	27
August	200	105	82	64	55	50	46	42	38	33	25	22	18
September	350	200	125	74	55	44	37	32	28	24	21	20	18
Period	580	340	265	195	155	125	100	84	66	50	35	27	19.5

Table 21. Maximum, minimum, and average of the monthly discharges, in acre-feet, for the period 1945-59. Nooksack River near Lynden.

	October	November	December	January	February	March	April	May	June	July	August	September
Maximum	341,600	443,500	464,800	447,400	437,500	335,700	351,700	423,400	441,900	338,200	209,900	240,100
Minimum	57,940	56,650	111,100	92,930	90,210	104,200	161,500	272,000	213,000	137,600	86,820	74,870
Average	201,950	250,680	274,110	246,290	217,890	182,200	217,650	328,840	311,480	226,960	130,360	115,270

Table 22. Discharge, in cubic feet per second, equaled or exceeded for specified percent of time--1946-59. Nooksack River near Lynden.

	Percent of time												
	1	5	10	20	30	40	50	60	70	80	90	95	99
October	19,000	9,500	6,700	4,500	3,400	2,700	2,200	1,850	1,520	1,270	1,030	900	770
November	21,000	10,800	7,800	5,700	4,600	4,000	3,400	2,800	2,200	1,700	1,250	950	680
December	19,000	11,300	8,800	6,400	5,200	4,300	3,600	3,100	2,600	2,150	1,700	1,400	1,000
January	15,000	9,500	7,300	5,400	4,300	3,600	3,000	2,600	2,200	1,800	1,300	1,000	780
February	19,000	10,000	7,500	5,300	4,100	3,300	2,800	2,360	2,000	1,660	1,360	1,200	1,000
March	9,500	5,800	4,700	3,800	3,200	2,800	2,500	2,200	2,000	1,750	1,550	1,450	1,320
April	12,500	6,600	5,400	4,600	4,100	3,700	3,300	3,000	2,700	2,400	2,000	1,850	1,600
May	11,000	8,800	7,700	6,600	6,000	5,400	5,000	4,600	4,200	3,700	3,100	2,650	2,000
June	12,500	9,300	8,000	6,600	5,800	5,300	4,800	4,400	4,100	3,700	3,300	3,000	2,600
July	7,600	6,400	5,800	5,000	4,400	3,900	3,500	3,100	2,800	2,500	2,200	2,050	1,850
August	6,000	3,700	3,100	2,600	2,300	2,100	1,900	1,800	1,650	1,500	1,350	1,280	1,150
September	8,000	4,300	3,200	2,300	1,900	1,650	1,500	1,350	1,280	1,190	1,100	1,040	950
Period	14,000	8,400	6,600	5,100	4,300	3,700	3,100	2,600	2,200	1,800	1,400	1,180	870

Table 23. Maximum, minimum, and average of the monthly discharges, in acre-feet, for the period 1949-59. Fishtrap Creek at Lynden.

	October	November	December	January	February	March	April	May	June	July	August	September
Maximum	2,090	4,460	6,510	7,010	9,010	7,260	5,050	2,910	1,240	680	510	660
Minimum	270	270	930	1,710	2,530	2,030	1,230	850	450	260	160	140
Average	770	2,310	3,950	4,060	4,490	3,730	2,650	1,550	860	520	360	340

Table 24. Discharge, in cubic feet per second, equaled or exceeded for specified percent of time--1949-59. Fishtrap Creek at Lynden.

	Percent of time												
	1	5	10	20	30	40	50	60	70	80	90	95	99
October	88	37	24	15.5	11.7	9.4	7.8	6.7	5.8	5.1	4.3	3.8	3.2
November	180	110	85	60	46	36	28	21	15	9.8	5.8	4.7	3.7
December	250	160	125	93	75	62	51	43	35	27	19	14	6.6
January	280	170	130	92	74	61	51	43	36	30	24	20	15
February	340	200	150	110	85	70	56	47	40	33	26	22	16
March	240	140	110	80	65	56	49	43	38	34	30	28	26
April	180	95	72	54	46	40	36	33	30	27	23	20	15
May	88	55	43	33	28	24	21	19	17	15	13	11.8	10
June	37	26.5	22	18	16	14	13	11.7	10.6	9.5	8.3	7.6	6.7
July	17	13.4	12	10.5	9.6	9.0	8.4	7.9	7.4	6.6	5.4	4.3	3.4
August	12	9.0	8.0	7.1	6.8	6.4	6.0	5.6	4.9	4.2	2.9	2.3	1.7
September	21	11.6	9.0	7.0	6.1	5.5	5.1	4.7	4.4	3.9	3.0	1.9	1.0
Period	200	110	82	55	40	30	21	14	10	7.2	5.2	4.1	2.4

Table 25. Maximum, minimum, and average of the monthly discharges, in acre-feet, for the period 1949-53. Dakota Creek near Blaine.

	October	November	December	January	February	March	April	May	June	July	August	September
Maximum	760	6,610	7,720	7,460	9,200	8,120	3,350	1,090	440	200	210	140
Minimum	110	90	400	1,030	2,710	1,880	759	490	200	100	90	80
Average	310	2,030	4,140	4,600	5,040	3,910	1,480	770	310	160	130	120

Table 26. Discharge, in cubic feet per second, equaled or exceeded for specified percent of time--1945-53. Dakota Creek near Blaine.

	Percent of time												
	1	5	10	20	30	40	50	60	70	80	90	95	99
October	30	13	9.0	6.0	4.7	3.8	3.4	3.0	2.6	2.3	2.0	1.8	1.6
November	300	180	115	50	15	9.0	6.5	4.7	3.5	2.4	1.5	1.2	1.0
December	430	220	150	95	67	50	37	27	20	12	6.2	4.2	2.5
January	480	250	180	115	85	62	47	35	25	17	10.5	8.2	6.5
February	540	280	200	130	95	73	56	44	33	24	16	12	8.5
March	540	250	150	82	58	44	36	30	25	22	17.5	15	12
April	155	70	48	32	24	20	17	15	13	11	9.3	8.4	7.0
May	90	31	23	17	13	10.5	8.6	7.4	6.4	5.5	4.6	4.1	3.5
June	22	10.5	8.3	6.6	5.7	5.0	4.5	4.0	3.5	3.1	2.6	2.2	1.7
July	6.5	4.2	3.6	3.0	2.8	2.6	2.4	2.3	2.2	2.1	1.9	1.6	1.2
August	5.3	3.8	3.3	2.7	2.3	2.1	1.9	1.8	1.6	1.4	1.1	0.9	0.7
September	4.2	3.3	2.9	2.5	2.2	2.0	1.9	1.7	1.5	1.4	1.2	1.1	0.9
Period	320	140	85	42	24	14	7.8	4.7	3.2	2.4	1.7	1.3	1.0

RUNOFF MAP

Meteorological data for the study area indicates that the years 1934 through 1959 contain a complete climatic cycle. Most reliable precipitation and streamflow records available for the report were also obtained during this period, therefore, all streamflow studies were based on data obtained during that time. All precipitation and continuous stream gage records were first adjusted so they would be representative of this 26-year period. This was accomplished through use of the discharge ratios described in the preceding section on basic data and by methods discussed in the section on climate. Mean annual evapotranspiration losses as computed by the Thornthwaite procedure were then applied to precipitation data in order to estimate values of runoff.

Drainage areas contributing flow to each gage were studied to determine the effects of certain environmental factors on precipitation and runoff. Of all variables involved, elevation appears to have the greatest influence, but its effect is not consistent from one region to another. This inconsistency results from various modifying factors such as average land slope, basin orientation with respect to prevailing winds and storm paths, the influence of nearby mountains to shield the basin from storms, time of year, types of vegetative cover, and a multitude of other variables too numerous to mention. It is an impossible task to determine what effect each of the many variables would have upon precipitation and runoff in any one area, but a close approximation can be obtained by studying the more important ones. This was done, and the resulting information then used to construct a map showing runoff isopleths or lines of equal runoff (pl. 6). These lines are similar to isohyetal lines on a precipitation map, and in like manner can be used to estimate total mean annual runoff from any part of the report area. It should be stressed, however, that they represent average conditions that have occurred over a period of 26 years and it does not mean that this same amount and distribution of runoff will occur during every water year.

It also must be pointed out that this map most likely contains discrepancies caused by the scarcity and inherent inadequacies of the basic data used in its construction. The regions of greatest doubt are above 7,000 feet near the summit of Twin Sisters Mountain, Mt. Baker, and Mt. Shuksan; and short dashed lines are used in these areas to indicate the higher degree of uncertainty.

STREAMFLOW ANALYSIS AND EVALUATION

All basic streamflow data in the report area were compiled by the U. S. Geological Survey and summarized in tables 2 and 3. Although basic data is the primary source of information, in many instances it does not present a true picture of average conditions over a long period of time. It, therefore, becomes essential to analyze and interpret basic information so that meaningful conclusions can be drawn.

In the Nooksack River area, major streams were broken-down into their most important tributaries and then evaluated in order to gain such information. Surface-water maps of Whatcom Basin and the Eastern Upland, which provide easy reference to all the streams, are enclosed at the end of this report (pls. 4 and 5). To avoid confusion every stream in the analysis was evaluated in its entirety above its confluence with another tributary or stream.

In order to locate any particular point of confluence, a system of numbering was developed. Beginning with zero at the mouth, or where a stream flows across the international border, each primary tributary confluence with the main stream was numbered consecutively in an upstream direction. Using the primary confluence number as a base, a similar consecutive numbering system was then applied to the branches of each primary tributary to indicate secondary points of confluence and so on until every confluence point was numbered. In all cases each additional number was separated from the other base numbers by a colon and the order of magnitude of any tributary is then determined by merely counting these groups of numbers. It should be noted that several streams shown on the Whatcom Basin surface-water map have junctions but do not have confluence numbers. Those junctions usually represent large diversion ditches or effluent streams and consequently cannot be considered as points of confluence.

A detailed summary of the surface-water analysis is presented in table 27. Although this streamflow study was generally quite comprehensive, it was necessary to omit certain areas near the coast because they were affected by tidal action. Several small streams and tributaries inland were also omitted from the discussion because of their relative unimportance, but runoff in these areas can easily be estimated through use of the runoff map described previously. In all cases, every stream in the table is referred to both by name and confluence number and all streamflow information refers to the stream system and drainage area contributing flow above the point of confluence.

All drainage areas listed in the table are within the United States unless otherwise indicated and refer only to surface drainage areas as established by topographic divides. Baseflow contributions may or may not originate from this same area depending mainly upon local geology within and adjacent to the basin. If ground water exists under water table conditionsrather than being confined, the area contributing baseflow is to a large extent controlled by the position of the groundwater or phreatic divide.

Scientific exploration in the field of hydrology has not yet found an accurate way to predict streamflow in advance without relying upon a statistical analysis of events that have occurred in the past. This leads to a discussion of streamflow in terms of maximum, minimum, and mean flows and their corresponding probabilities of occurrence. Most streamflow records in the Nooksack area are of insufficient duration to warrant good probability studies. However, a great amount of knowledge is still provided by determining maximum, minimum, and mean values from past records. Estimates of the total mean annual runoff adjusted for the past 26-year period are presented in table 27 in terms of acre-feet and inches of water on the basin. If a comparison is made, it will be seen that these figures compare favorably with those on the runoff map.

The last two columns in table 27 represent estimates of low flow and the probable times of the year they can be expected to occur. If streamflow hydrographs of a particular gage are examined, it is evident that the lowest flows are seldom identical from year to year. Over a period of time, however, it can be seen that annual low flows will generally approximate the same order of magnitude each year. Estimated values in the table were, therefore, presented in round numbers to reasonably approximate these magnitudes and are not intended to represent the absolute lowest flows that have occurred unless the stream actually dries up. In most cases, these figures can also be interpreted to mean flows that can be expected in equal magnitude or less from 1 to 5 percent of the time during any one year.

Table 27. Streamflow Evaluation.

Confluence Number	Name of Stream Above Confluence	Surface Drainage Area Square Miles	Estimated Mean Annual Runoff From Drainage Area Inches	Acre Feet	Estimated Average Low Flow and Usual Periods of Occurrence Second Feet	Months
			NOOKSACK RIVER DRAINAGE BASIN			
			North Fork Nooksack River			
55	North Fork Nooksack River	70.1	99	370,000	120	Feb., Mar., Sept., Oct.
55	Wells Creek	24.2	101	131,000	30	Feb., Mar., Sept., Oct.
47	Glacier Creek	32.2	85	146,000	40	Feb., Mar., Sept., Oct.
42	North Fork Nooksack River	161.5	86	740,000	210	Feb., Mar., Sept., Oct.
42	Canyon Creek	30.9	75	123,000	15	Feb., Mar., Sept., Oct.
38	Boulder Creek	8.6	77	35,400	2	Sept., Oct., Nov.
35	Maple Creek	11.0	60	35,200	2	Sept., Oct., Nov.
31	Kendall Creek	30.0, * 25.1	49	78,500	4	Sept., Oct., Nov.
30	North Fork Nooksack River	263.7, *258.7	77	1,080,000	260	Jan., Feb., Aug., Sept.
30	Coal Creek	4.6	59	14,300	0.5	Aug., Sept.
29	Racehorse Creek	11.1	74	43,600	3	Aug., Sept.
27	Bells Creek	5.0	57	15,100	0.5	Aug., Sept.
26	North Fork Nooksack River	292.9, *288.0	76	1,190,000	290	Jan., Feb., Aug., Sept.
			Middle Fork Nooksack River			
26:10	Middle Fork Nooksack River	46.4	88	218,000	120	Feb., Sept., Oct.
26:10	Clearwater Creek	21.2	83	94,000	20	Feb., Sept., Oct.
26:4	Porter Creek	4.7	75	19,000	0.5	Aug., Sept., Oct.
26:1	Canyon Creek	8.8	78	36,400	4	Aug., Sept., Oct.
26	Middle Fork Nooksack River	101.2	80	432,000	170	Feb., Aug., Sept., Oct.
			Nooksack River			
23	Nooksack River	400.2, *395.3	77	1,630,000	500	Jan., Feb., Sept., Oct.
			South Fork Nooksack River			
23:37	South Fork Nooksack River	50.2	105	281,000	40	Aug., Sept., Oct.
23:37	Howard Creek	7.5	103	41,500	5	Aug., Sept., Oct.
23:22	Cavanaugh Creek	9.7	98	50,500	6	Aug., Sept., Oct.
23:19	South Fork Nooksack River	103.4	97	535,000	90	Aug., Sept., Oct.
23:19	Skookum Creek	23.0	75	92,300	25	Feb., Mar., Sept., Oct.
23:14	Hutchinson Creek	14.7	64	50,000	8	Aug., Sept., Oct.
23:4	Black Slough	6.9	51	18,700	0	Aug., Sept., Oct.
23	South Fork Nooksack River	181.6	81	785,000	180	Aug., Sept., Oct.
			Nooksack River			
22	Nooksack River	584.2, *579.3	78	2,430,000	750	Jan., Feb., Sept., Oct.
			Smith Creek			
19	Smith Creek	10.6	51	28,800	0.3	July, Aug., Sept.
			Anderson Creek			
18:3	Anderson Creek	2.0	50	5,400	0.1	July, Aug., Sept.
18:3	North Unnamed Stream	3.5	51	9,400	0.1	July, Aug., Sept.
18	Anderson Creek	14.3	36	27,800	0.2	July, Aug., Sept.
			Stickney Slough			
17:2	Kamm Ditch	4.3	23	5,200	3	Aug., Sept., Oct.
17:2	Mormon Ditch	2.5	21	2,900	0.2	Aug., Sept., Oct.
17	Stickney Slough	7.9	22	9,200	5	Aug., Sept., Oct.
			Scott Ditch			
16:3	Scott Ditch	3.2	21	3,700	1.5	Aug., Sept.
16:3	Elder Ditch	2.7	19	2,100	1.5	Aug., Sept.
16	Scott Ditch	9.8	20	9,700	4	Aug., Sept.

* Portion of Drainage Area in the United States.

Table 27. Streamflow Evaluation. (Continued)

Confluence Number	Name of Stream Above Confluence	Surface Drainage Area	Estimated Mean Annual Runoff From Drainage Area		Estimated Average Low Flow and Usual Periods of Occurrence	
		Square Miles	Inches	Acre Feet	Second Feet	Months
		NOOKSACK RIVER DRAINAGE BASIN				
		Nooksack River				
15	Nooksack River	645.6, *640.7	74	2,540,000	930	Jan., Feb., Sept., Oct.
		Fishtrap Creek				
14:4	Fishtrap Creek	16.5, *4.0	28	24,300	4	Aug., Sept., Oct.
14:4	Bender Ditch	2.1, *1.4	23	2,500	0.4	Aug., Sept., Oct.
14:3	Depot Ditch	3.7, *3.1	23	4,500	0.8	Aug., Sept., Oct.
14:2	Benson Ditch	1.0	22	1,100	0.2	Aug., Sept., Oct.
14:1:2	Double Ditch	**2.7	26	3,700	5	Aug., Sept., Oct.
14:1	Double Ditch	4.3, *1.6	23	5,300	3.5	Aug., Sept., Oct.
14	Fishtrap Creek	30.6, *14.1	26	43,000	10	Aug., Sept., Oct.
		Bertrand Creek				
13:6	Bertrand Creek	22.2, *2.4	26	30,800	5	Aug., Sept., Oct.
13:6	Van Ditch	4.4, *1.5	25	5,900	0.7	Aug., Sept., Oct.
13:4	McClelland Creek	2.5	23	3,200	0.4	Aug., Sept., Oct.
13:2	North Unnamed Stream	3.8	22	4,500	0.6	Aug., Sept., Oct.
13:1	Duffner Ditch	4.3, *4.1	21	4,800	1	Aug., Sept., Oct.
13	Bertrand Creek	43.5, *20.5	24	56,000	9	Aug., Sept., Oct.
		Schneider Ditch				
10	Schneider Ditch	5.1	15	4,100	0.5	Aug., Sept.
		Wiser Lake Creek				
9:3	Wiser Lake Creek (Wiser Lake Outlet)	3.7	17	3,300	1.5	Aug., Sept.
9	Wiser Lake Creek (Cougar Creek)	7.0	15	5,800	1.8	Aug., Sept.
		Nooksack River				
2	Nooksack River	743.8, *699.5	67	2,650,000	1000	Jan., Feb., Sept., Oct.
		Tenmile Creek				
2:16	Tenmile Creek	4.4	21	5,000	0.3	Aug., Sept.
2:16	East Unnamed Stream	2.2	21	2,400	0.2	Aug., Sept.
2:10	Tenmile Creek	12.1	19	12,300	1	Aug., Sept.
2:10:1	Fourmile Creek (Green Lake Outlet)	7.1	21	8,600	1	Aug., Sept.
2:10	Fourmile Creek	10.6	19	11,600	1.5	Aug., Sept.
2:4	Tenmile Creek	25.8	19	26,200	3	Aug., Sept.
2:3:5	Deer Creek	3.5	20	3,700	0.3	Aug., Sept.
2:3	Deer Creek	6.8	17	6,200	1	Aug., Sept.
2	Tenmile Creek	34.0	18	33,400	5	Aug., Sept.
		Nooksack River				
0	Nooksack River	781.2, *736.9	64	2,690,000	1050	Jan., Feb., Sept., Oct.
		COASTAL AREA DRAINAGE BASINS				
		Dakota Creek				
13	North Fork Dakota Creek	7.9, *7.5	26	11,000	0.9	Aug., Sept.
13	South Fork Dakota Creek	9.0	22	10,500	0.7	Aug., Sept.
11	Dakota Creek	18.0, *17.5	23	22,200	1.6	Aug., Sept.
11	Haynie Creek	3.0	25	4,100	0.5	Aug., Sept.
4:1	East Unnamed Stream	1.7	25	2,200	0.4	Aug., Sept.
4:1	North Unnamed Stream	1.3	23	1,600	0.2	Aug., Sept.
2	Spooner Creek	1.6	22	1,900	0.1	Aug., Sept.
0	Dakota Creek	28.3, *27.8	23	34,400	3	Aug., Sept.

*Portion of Drainage Area in the United States.
**Total Drainage Area in Canada.

Table 27. Streamflow Evaluation.. (Continued)

Confluence Number	Name of Stream Above Confluence	Surface Drainage Area	Estimated Mean Annual Runoff From Drainage Area		Estimated Average Low Flow and Usual Periods of Occurrence	
		Square Miles	Inches	Acre Feet	Second Feet	Months
			COASTAL AREA DRAINAGE BASINS			
			California Creek			
12	California Creek	8.4	17	7,600	0.6	Aug., Sept.
12	East Unnamed Stream	2.6	15	2,100	0.2	Aug., Sept.
10	East Unnamed Stream	1.3	14	900	0.1	Aug., Sept.
9:1	Campbell Ditch	1.6	15	1,200	0.2	Aug., Sept.
9:1	West Unnamed Stream	2.0	14	1,400	0.1	Aug., Sept.
4	North Unnamed Stream	1.8	13	1,200	0.1	Aug., Sept.
0	California Creek	22.8	15	18,000	1.5	Aug., Sept.
			Terrell Creek			
13	Butler Ditch	2.1	18	2,000	0	Aug., Sept.
13	Terrell Lake Outlet	2.8	16	2,400	0	Aug., Sept.
12	Fingalson Creek	1.6	20	1,700	0	Aug., Sept.
6	South Unnamed Stream	2.2	15	1,700	0	Aug., Sept.
5	Terrell Creek	12.5	16	10,700	0	Aug., Sept.
5	South Unnamed Stream	0.9	15	700	0	Aug., Sept.
2	East Unnamed Stream	0.9	14	600	0	Aug., Sept.
1:2	East Unnamed Stream	1.4	14	1,100	0	Aug., Sept.
0	Terrell Creek	17.2	15	14,000	0	Aug., Sept.
			Lummi River and Delta Tributaries			
1	Schell Ditch	2.2	17	2,000	0.2	Aug., Sept.
9	West Unnamed Stream	1.4	16	1,100	0	Aug., Sept.
9	North Unnamed Stream	2.0	19	2,000	0	Aug., Sept.
8	East Unnamed Stream	1.1	18	1,100	0	Aug., Sept.
7	East Unnamed Stream	1.2	15	1,000	0.1	Aug., Sept.
4	North Unnamed Stream	9.5	16	8,000	0.2	Aug., Sept.
			Silver Creek			
11	Andreason Ditch	3.3	17	3,000	0.5	Aug., Sept.
11	Bear Creek	4.2	15	3,300	0.1	Aug., Sept.
6	Tennant Lake Creek	2.6	12	1,600	0	Aug., Sept.
3	East Unnamed Stream	0.9	10	500	0	Aug., Sept.
0	Silver	15.8	14	11,500	0.6	Aug., Sept.
			SUMAS RIVER DRAINAGE BASIN			
			Sumas River			
7	Dale Creek	1.5	45	3,600	0.2	Aug., Sept.
6	Goodwin Creek	3.3	34	5,900	3	Aug., Sept.
5	Sumas River	11.7	35	21,900	7	Aug., Sept.
5	Swift Creek	3.2	46	7,800	0.1	Aug., Sept.
4	Breckenridge Creek	7.5	42	16,700	0.6	Aug., Sept.
3	Kinney Creek	2.1	30	3,300	0.1	Aug., Sept.
1	Sumas River	34.2	35	63,200	12.5	Aug., Sept.
			Johnson Creek			
1:8	Johnson Creek	6.0	23	7,500	2	Aug., Sept.
1:8	Squaw Creek	3.8	23	4,800	1	Aug., Sept.
1:6	Pangborn Creek	3.3	25	4,400	2.8	Aug., Sept.
1:1	West Unnamed Stream	2.6, *1.4	27	3,800	1.5	Aug., Sept.
1	Johnson Creek	20.7, *19.6	24	26,900	12	Aug., Sept.
			Sumas River			
0	Sumas River	55.8, *54.6	31	91,300	25	Aug., Sept.

*Portion of Drainage Area in the United States.

Table 27. Streamflow Evaluation. (Continued)

Confluence Number	Name of Stream Above Confluence	Surface Drainage Area	Estimated Mean Annual Runoff From Drainage Area		Estimated Average Low Flow and Usual Periods of Occurrence	
		Square Miles	Inches	Acre Feet	Second Feet	Months
		SUMAS RIVER DRAINAGE BASIN				
		Saar Creek				
0	Saar Creek	10.1	41	22,000	0.2	Aug., Sept.
		Mud Slough				
0	Mud Slough (Arnold Slough in Canada)	3.3, *3.2	32	5,600	1	Aug., Sept.

*Portion of Drainage Area in the United States.

Table 28. Existing Lakes and Reservoirs in the Report Area.*

Location** Township	Range	Section	Name	Approximate elevation above sea level in feet	Approximate area in acres	Drainage
T36N	R7E	4	Three Lakes (Lake No. 1)	4,000	1	South Fork Nooksack River
			(Lake No. 2)	4,000	1	South Fork Nooksack River
			(Lake No. 3)	4,000	4	South Fork Nooksack River
		5	Heart Lake	4,050	15	South Fork Nooksack River
		5	Unnamed Lake	4,300	6.5	South Fork Nooksack River
		5	Unnamed Lake	4,650	1.5	South Fork Nooksack River
		6	Unnamed Lake	4,000	4.5	South Fork Nooksack River
		9	Bear Lake	3,550	4	South Fork Nooksack River
		12	Springsteen Lake	3,550	19.2	South Fork Nooksack River
T37N	R5E	7	Marona Millpond	350	2.5	South Fork Nooksack River
		16	Unnamed Lake	300	10	South Fork Nooksack River
		22	Ferguson Ponds		10	South Fork Nooksack River
		35	Athearns Ponds	450	5	South Fork Nooksack River
T37N	R6E	24	Unnamed Lake	5,200	5	South Fork Nooksack River
		34	Unnamed Lake	4,075	1.5	South Fork Nooksack River
T37N	R7E	7	Unnamed Lake	4,450	3	Middle Fork Nooksack River
		8	Hildebrand Lake	3,450	0.7	Middle Fork Nooksack River
		8	Wiseman Lake	4,250	18.6	Middle Fork Nooksack River
		9	Elbow Lake	3,400	5	South Fork Nooksack River
		9	Unnamed Lake	3,400	1.5	South Fork Nooksack River
		9	Dorreen Lake	3,380	1	South Fork Nooksack River
T37N	R8E	32	Tuckway Lake	3,850	1.5	South Fork Nooksack River
T38N	R1E	5	Unnamed Lake	10	1.5	Georgia Strait
T38N	R2E	4	Unnamed Lake	120	1.5	Silver Creek
		9(O.L.)	Lost Lake	140	3	Silver Creek
		10	Unnamed Lake	145	2	Silver Creek
		11	Taylor Pond	120	1	Silver Creek
T38N	R5E	6	Mud Lake	250	0.3	Nooksack River
		9	Williams Lake	350	3.5	South Fork Nooksack River
		9	Unnamed Lake	450	1	South Fork Nooksack River
		23	Unnamed Lake	690	1	Middle Fork Nooksack River
		23	Mosquitoe Lake	690	7	Middle Fork Nooksack River
		23	Unnamed Lake	720	1	Middle Fork Nooksack River
		23	Jorgensen Lake	690	12	Middle Fork Nooksack River
		23	Unnamed Lake	690	1	Middle Fork Nooksack River
T38N	R6E	35	Unnamed Lake	3,750	1	Middle Fork Nooksack River
T38N	R7E	21	Unnamed Lake	5,700	1	Middle Fork Nooksack River
		27	Hann Lake	5,100	0.5	Middle Fork Nooksack River
		27	Unnamed Lake	5,100	2.5	Middle Fork Nooksack River
		35	Mazama Lake	5,150	0.5	Middle Fork Nooksack River
T39N	R1W	1	Med-O-Land Reservoir	15	3.8	Terrell Creek
T39N	R1E	2	Unnamed Lake	70	1	California Creek
		4	Smrekar Reservoir	180	3	Terrell Creek
		6	Heide Pond	20	1.5	Terrell Creek
		16(O.L.)	Terrell Lake	212	438	Terrell Creek
		21	Unnamed Pond	212	1.8	Terrell Creek
		24	Nubgaard Reservoir "A"	280	11.5	Lummi River
T39N	R2E	3	Unnamed Lake	25	2.5	Nooksack River
		4	Unnamed Lake	45	1	Schneider Ditch
		4	Keefe Lake	25	4	Schneider Ditch
		7	Potts Pond	70	0.5	California Creek
		9	Unnamed Lake	25	1	Nooksack River
		10(O.L.)	Unnamed Lake	30	3.5	Wiser Lake Creek
		15	Unnamed Lake	60	1.5	Nooksack River
		21(O.L.)	Unnamed Lake	20	1.5	Nooksack River
		21(O.L.)	Barrett Lake	20	40	Tenmile Creek
		32(O.L.)	Tennant Lake	15	43	Silver Creek
		32	Unnamed Lake	20	1	Silver Creek
		33	Unnamed Lake	20	1	Silver Creek
		33	Brennan Pond	15	11.7	Silver Creek
T39N	R3E	4	Fountain Lake	70	14	Scott Ditch
		6	Wiser Lake	50	123	Wiser Lake Creek
		9(O.L.)	Green Lake	74	19.5	Tenmile Creek
		13	Fazon Lake	128	33	Tenmile Creek
		27	Unnamed Lake	285	1.5	Tenmile Creek
T39N	R4E	9	Unnamed Lake	100	5	Sumas River
		28	Unnamed Lake	230	1	Nooksack River
T39N	R6E	9	Three Small Unnamed Lakes	4,200	3	North Fork Nooksack River
		30(O.L.)	Canyon Lake	2,250	45	Middle Fork Nooksack River
T39N	R8E	4	Pinus Lake	2,450	1.5	North Fork Nooksack River
		13	Unnamed Lake	5,000	5	North Fork Nooksack River
		23	Arbuthnot Lake	4,800	5	North Fork Nooksack River
		23	Hayes Lake	4,800	13	North Fork Nooksack River
		23	Mazama Lake	4,800	0.8	North Fork Nooksack River
		24	Iceberg Lake	4,800	36.6	North Fork Nooksack River

Table 28. Existing Lakes and Reservoirs in the Report Area.* (Continued)

Location** Township	Range	Section	Name	Approximate elevation above sea level in feet	Approximate area in acres	Drainage
T39N	R9E	17	Picture Lake	4,100	3	North Fork Nooksack River
		17	Highwood Lake	4,100	2	North Fork Nooksack River
		18	Terminal Lake	4,240	0.3	North Fork Nooksack River
		19	Lower Bagley Lake	4,200	11	North Fork Nooksack River
		19	Upper Bagley Lake	4,240	9	North Fork Nooksack River
		19	Austin Pass Lake	4,450	0.8	North Fork Nooksack River
		23	Price Lake	3,895	40	North Fork Nooksack River
T40N	R3W	9	Unnamed Lake	10	1.2	Georgia Strait
T40N	R1E	4	Blaine Reservoir	140	1.5	Dakota Creek
		5	Olason Reservoir	70	1	Dakota Creek
		14	Unnamed Lake	60	1	Dakota Creek
		24	Leland Pond	45	0.7	Dakota Creek
T40N	R2E	8	Unnamed Lake	130	1	Dakota Creek
		27	Unnamed Lake	50	3.5	Bertrand Creek
		27	Willey Lake	50	4	Schneider Ditch
		34	Harksell Lake	25	0.3	Schneider Ditch
T40N	R3E	1	Pangborn Lake	130	30	Johnson Creek
		20	Lynden Juvenile Pond	100	0.5	Fishtrap Creek
T40N	R5E	6	Unnamed Lake	50	1.5	Mud Slough
		7	Anderson Lake	500	2.5	Mud Slough
		10	Unnamed Lake	500	1	North Fork Nooksack River
		27(O.L.)	Kendall Lake	490	12	North Fork Nooksack River
		31	Lost Lake	2,850	4.4	Sumas River
T40N	R6E	7(O.L.)	Silver Lake	780	184	North Fork Nooksack River
		12	Bald Lake	4,400	2.5	North Fork Nooksack River
T40N	R7E	13	Church Lake (Upper Bear Paw Mt. Lake)	5,150	4	North Fork Nooksack River
		13	(Lower Bear Paw Mt. Lake)	4,450	6.5	North Fork Nooksack River
		23	Whistler Lake	5,575	2.5	North Fork Nooksack River
		27	Kidney Lake No. 1	5,500	0.6	North Fork Nooksack River
			Kidney Lake No. 2	5,500	0.9	North Fork Nooksack River
T40N	R8E	20	Canyon Lake	4,775	2	North Fork Nooksack River
T40N	R9E	16	Twin Lakes (Upper Twin Lake)	5,200	17	North Fork Nooksack River
			(Lower Twin Lake)	5,180	20	North Fork Nooksack River
T41N	R3E	36	Unnamed Lake	152	1	Judson and Laxton Lakes
T41N	R4E	31	Judson Lake	152	112	Judson and Laxton Lakes
		33	Van Valkenberg Pond	50	1	Johnson Creek

* Tabulation includes unnamed lakes one acre or more in surface area and all known named lakes.

** The major portion of a lake or reservoir lies in the township, range, and section listed unless followed by "(O.L.)" which indicates the outlet location.

All low flow estimates were based upon partial or miscellaneous measurements and continuous stream gage records taken in this area by the U. S. Geological Survey. In some cases the estimates were determined from many observations, while in others from only meager information. Certain values in the tabulation can, therefore, be given greater confidence than others depending upon the quantity and quality of data used.

Unfortunately no data were ever collected at the time of these low flow measurements to determine how much upstream diversion or consumptive use was being made of waters in the stream. In most cases, it is impossible to state whether or not low flow measurements and subsequent estimate of the average low flow are affected by such use. Owing to the fact, however, that most low flows occur during the summer when irrigation withdrawals are at a peak, it is quite probable that many measurements were affected by upstream use up to the limit of water rights in the area.

NORTH FORK NOOKSACK RIVER

The North Fork of the Nooksack River originates from East Nooksack Glacier near the base of 9,000 foot high Mt. Shuksan and flows through a rocky, heavily wooded canyon which gradually flattens out into a relatively low valley. From here the river flows in a westerly and eventually southerly direction, picking up many small tributaries, until it meets the Middle Fork where the two become the main stem of the Nooksack River. Many major tributaries such as Wells Creek and Glacier Creek also originate from snow fields and glaciers and similarly follow steep, rocky courses in their upper reaches.

Above its confluence with the Middle Fork, the North Fork drains an area of about 293 square miles and contains elevations from less than 300 feet to more than 10,000 feet above mean sea level datum. Large variations in precipitation are associated with these extreme elevation differences, but the extent of this variability and its distribution is not well-defined by the existing gage network in the basin. With the exception of the station at Mt. Baker Lodge, all precipitation stations are situated at low elevations in the sheltered, deep, narrow North Fork canyon and obviously do not receive samples that are representative of higher areas. (fig. 2).

Snowpack data has been collected in this watershed since 1957 when a snow survey course was established on top of 4,300 foot high Panorama Dome just above Mt. Baker Lodge. Several other courses exist across the divide in the Baker River drainage, but none of these have a longer period of record than the Panorama course and at most can only infer what conditions would be like in the Nooksack River watershed.

Continuous daily discharge records have been collected on the North Fork below Wells, Cascade, and Canyon Creeks; at two locations on Kendall Creek near Kendall; and on Coal Creek. Of these, the station below Cascade Creek has the longest period of record and offers the most reliable hydrologic information. Information provided by the other gages is relatively meager and though certain tendencies are indicated, these records are generally of insufficient duration to indicate long-time trends. Based on these data and various miscellaneous measurements, annual runoff produced by the North Fork was estimated to average about 76 inches or somewhat more than one million acre-feet. This far exceeds that of either the Middle or South Fork and is usually about equal to their combined runoff.

Hydrographs of the North Fork taken below Cascade Creek show a highly variable pattern throughout the year, but two rather distinct low flow periods are indicated. One of these periods generally occurs during the months of January and February and the other later on in August and September. The more pronounced low flows usually occur during the cold winter season when most high elevation streams are frozen and precipitation is accumulating on the basin in the form of snow. During this time of the year the average of minimum daily discharges recorded at the gage below Cascade Creek was about 180 cubic feet per second. No low flow measurements were ever made on the North Fork just above its confluence with the Middle Fork, but based on an analysis of tributary contributions, the average low flow at this point should be around 290 cubic feet per second.

Approximately one-third of the North Fork's total annual flow originates from the watersheds of Wells, Glacier, and Canyon Creeks. Glacier Creek and Wells Creek together drain almost one-half of the area on the slopes of Mt. Baker and produce the greatest amount of runoff per unit area with the exception of a few small streams farther east that originate on the slopes adjacent to Mt. Shuksan. A comparison of the area-distribution with elevation in the Wells and Glacier Creek watersheds shows that Wells Creek has a higher mean basin elevation than Glacier Creek. Wells Creek basin, therefore, receives more precipitation and produces more runoff per unit area than Glacier Creek basin even though its exposure and orientation are somewhat less favorable. The watersheds of Canyon Creek and Glacier Creek are similar in size, but a greater percentage of the Canyon Creek watershed is distributed at lower elevations thereby producing considerably less precipitation and runoff.

It is difficult to accurately predict low summer flows for these three streams, but it is safe to assume that Canyon Creek will be the lowest because there are no permanent snow and ice fields in this watershed. Glacier Creek basin, like its name implies, contains the larger amount of permanent ice and is generally much better exposed to melting than the Wells Creek watershed. This, in combination with its greater drainage area, produces the largest low flow of the three. Low flows on these streams during winter months are even more difficult to predict and depend mainly on the extent of freezing within the basin, which is in turn primarily a function of elevation. On this basis, the Wells Creek flow should drop most and that of Canyon Creek least.

Boulder and Maple Creeks drain areas on the north side of the North Fork of the Nooksack River, but produce less runoff per unit area than other basins farther upstream primarily because of the lower mean elevation of their watersheds. Boulder Creek basin is considerably higher and more favorably situated than the Maple Creek watershed, resulting in somewhat greater annual runoff even though its drainage area is significantly smaller.

Low flows on these and other nearby streams almost always occur in late summer or early fall with actual time of occurrence and magnitude depending primarily upon the intensity, frequency, and duration of summer storms in the area. The probability of summer precipitation and consequent runoff occurring in these areas is somewhat greater than in the flat Whatcom Basin region, but small intramontane valleys like these are not geologically suited to accumulate large quantities of ground water. Consequently, there is little storage to maintain baseflow after direct storm runoff has passed. As a result many small streams in the area not heading in perennial ice fields become intermittent during this time of the year. Maple Creek is an exception as it has some ground-water storage and discharge from Silver Lake to maintain its baseflow. Although streamflow measurements of Kendall Creek record an approximate annual runoff of only 20 inches, in reality the contribution of this stream is probably considerably greater. Permeable glacial deposits on the floor of this valley absorb much of the runoff and this does not reappear at the surface until it has reached the lower end of the basin beyond the point where the stream was gaged. This is evident from the fact that perennial surface streams are nonexistent in the upper portion of the flat Columbia Valley but appear in the lower part just before joining the North Fork. Hydrographs of Kendall Creek also indicate that direct runoff contributes very little to its total flow. These graphs show none of the sharp, high peaks characteristic of direct runoff but show a rather smooth, continuing curve typical of baseflow conditions. The lowest flows on Kendall Creek also occur in late summer, but because of the rather steady ground-water contribution, these flows are more consistent from year to year than those of neighboring streams.

Other small tributaries of some importance near the lower end of the North Fork are Coal, Racehorse, and Bells Creeks. These streams, because of their low elevations, are primarily rain-fed; but at times during winter months, relatively small amounts of snow will accumulate on the upper parts of their watersheds. Very little factual information is available on the flow characteristics of these streams, but based on their hydrologic location, they are probably quite similar to Canyon Creek on the Middle Fork near Kulshan (see figs. 14, 26, 27, 28, and 29).

The most outstanding feature of hydrology in the watershed of the North Fork of the Nooksack River is the large amount of natural storage occurring throughout regions of high elevation in the form of snow and perennial ice. Snow fields that build up during winter blanketing most of this area release their waters gradually as temperatures increase in spring and early summer, thus providing a major part of streamflow from March through July. Glacial melt occurs somewhat later after most of the snow cover has dissipated and continues on throughout summer and fall. Both of these large reservoirs, therefore, serve as natural runoff regulators by storing precipitation when it is most abundant and releasing it again during the growing season when it is most needed. This can be proven by the total difference in runoff between the South and North Forks of the Nooksack River during the summer period. At this time, for equal size drainage areas, the glacial-fed North Fork produces approximately 140,000 acre-feet more than the South Fork.

Smaller amounts of natural surface storage also exist in the North Fork watershed in numerous small lakes, but most of these are located in remote areas and mainly provide recreational value. For convenience, all available data on these lakes and others in the report area are listed in table 28.

MIDDLE FORK NOOKSACK RIVER

The Middle Fork of the Nooksack River heads at the end of the Deming Glacier located on the southwest slopes of Mt. Baker and falls sharply to the main river valley a short distance below. Here, it makes an abrupt turn and flows in a northwesterly direction to its confluence with the North Fork near the settlement of Kulshan. Topography of the Middle Fork area has generally the same features that characterize the the North Fork basin. The terrain varies from high glaciated peaks surrounded by lower densely timbered mountains to narrow gravel-mantled stream valleys.

The Middle Fork basin occupies more than 100 square miles or about one-eighth of the total area drained by the Nooksack River system, and it exhibits a range in elevation from 300 feet above sea level to 10,778 foot high Mt. Baker. Most of the drainage area lies on the northeast side of the main stem where there is a generally favorable southwest exposure. This exposure causes the northeast side of the watershed to intercept larger quantities of precipitation than the opposite side, which lies in a rain shadow behind Bowman Mountain, Twin Sisters Mountain, and the Sisters Divide. Probably the heaviest precipitation in the study area falls on Mt. Baker's southwest slopes near the Middle Fork headwaters, but no actual records exist to prove this. The only information to substantiate this assumption is provided by a storage gage located in Schriebers Meadow just across the divide in the Baker River drainage. Although the gage is situated at the relatively low elevation of 3,400 feet, during the first year and one month of operation, from August, 1958, to September, 1959, 184 inches of precipitation were recorded. Actually no precipitation records of any kind are available from points within the Middle Fork basin itself, and other than the gage just mentioned, the nearest precipitation station is in the town of Deming. As indicated on the Physiographic Province Map showing mean annual precipitation (fig. 2), this station has measured an average of 56 inches per year.

Continuous stream gage information on the Middle Fork proper is limited to a little more than two years of records taken about fourteen years apart at a site situated about half a mile above the Heislers Creek confluence. In contrast to this, there are five consecutive years of record available on Canyon Creek near Kulshan. These records are rated as good, and provide a reliable indication of runoff conditions in this and similar nearby basins. Various miscellaneous measurements made throughout the basin are also available from the U. S. Geological Survey, but their use is limited to estimating low flows. Based on all available data, the Middle Fork's mean annual runoff has been estimated to be over 400,000 acre-feet, which is equivalent to about 80 inches of water over the entire basin.

Low flow characteristics of the Middle Fork, similar to those of the North Fork, exhibit two well-defined periods during late summer and winter. In the upper reaches the more pronounced low flows occur coincident with freezing temperatures, while in summer glacial firn melt usually maintains higher flows. In contrast to this, it is difficult to predict which season will produce the lowest flows along lower reaches of the main river as there is no perennial ice to feed major tributaries in this area and the region is not subject to prolonged periods of freezing during winter. These factors produce a counterbalancing effect that maintains flow reasonably well throughout crucial periods, and as a result, it is estimated that the flow above the Middle Fork's confluence with the North Fork under present conditions will seldom be less than 170 second feet. In the future, however, when the city of Bellingham begins to divert water from this fork into Lake Whatcom to amplify its existing municipal water supply, this figure will be altered considerably.

Owing to the unbalanced drainage area distribution in this watershed, most major tributaries are located in the northern part of the basin. Of these Clearwater Creek, which joins the main stem a little more than a mile above Heislers Ranch, is by far the largest. This stream drains more than one-fifth of the Middle Fork basin and has an estimated average annual discharge close to 100,000 acre-feet. As the name implies, its waters are basically free of turbidity, being derived entirely from snowmelt and rain with no glacier melt contribution. Records for this stream are too meager to arrive at a well-defined conclusion, but its location infers that the lowest flows most often occur during the dry summer period. On the other hand, a prolonged cold spell during winter could very easily produce the minimum flow, but the probability of such an occurrence is less likely because much of the basin lies at relatively low elevations.

The comparatively long record on Canyon Creek shows a pattern of high flows during the months of December, January, and February, which is the result of extended winter precipitation falling mainly in the form of rain. Another peak is apparent in May or June when the small snowpack that has accumulated at higher elevations melts and runs off. After this peak has receded, a single low flow period follows in August and September. In addition to Canyon Creek, the pattern just described is characteristic of other small streams, such as Porter and Heislers Creeks near the lower end of the basin, and for the most part it also applies to Racehorse, Coal, and Bells Creeks, which are similarly situated at the lower end of the North Fork basin. Annual runoff from most of these streams is relatively small, but on a unit area basis those having an unobstructed southwest exposure usually produce somewhat larger amounts.

Snow and ice fields again represent the most important forms of natural surface storage in the Middle Fork basin. As in the case of the North Fork, snowpacks accumulate in winter over a major portion of the watershed, but glacial ice is more limited, being confined to the slopes of Mt. Baker and the north side of Twin Sisters Mountain. Many lakes in the region also provide some natural storage and data for these are listed in table 28.

SOUTH FORK NOOKSACK RIVER

The South Fork of the Nooksack River has its source on the high slopes south and east of Sister Divide and Twin Sisters Mountain. As it descends to the valley below, its course describes a large clockwise spiral arc until it eventually joins the main stem of the Nooksack River immediately above the town of Deming. For the most part, the terrain found in the South Fork's 180 square miles of drainage area is comparable in ruggedness to that of the North and Middle Forks, but elevations are somewhat lower, ranging between 200 and 7,000 feet.

As in the case of the Middle Fork, most of the area and all of the major tributaries lie on the north side of the river. This side also exhibits higher elevations, which have a tendency to induce a more pronounced orographic effect on storms than that produced by the opposite side. As a result of these factors and the generally advantageous southwest exposure, the South Fork watershed appears to receive precipitation comparable to the other two major forks in spite of its lower mean elevation.

Continuous streamflow records are presently obtained at only two points within the South Fork watershed, but both of these stations are rated as good and provide some of the most reliable information available in the Nooksack River basin. The better of the two is the gage on the South Fork itself, situated near the town of Wickersham and about three-quarters of a mile upstream from Skookum Creek. This gage has been in operation since 1933, and exhibits a longer record than any other streamflow station in the report area. The period of record, in fact, was long enough to encompass the 26-year period upon which studies in this report are based and, therefore, was employed as an indicator to estimate conditions in other parts of the Nooksack area where fewer and shorter records have been collected. The second gage is located on Skookum Creek a short distance above its confluence with the South Fork. This station was initiated in 1948, and although its record does not extend over as long a period as the South Fork gage, it still represents one of the more useful records in the area covered by this report. In addition fragmentary records were obtained on the South Fork at Saxon Bridge about a mile below Skookum Creek, and a few miscellaneous measurements were made at various points within the area.

Nearly 30 percent of the Nooksack River's total annual discharge is derived from that part of the basin drained by the South Fork. The actual amount approaches 800,000 acre-feet, which if evenly distributed, would amount to more than 80 inches of water on the basin. Low flows show up on the South Fork during the same two periods that are characteristic of the other two forks, but the lowest flows practically always occur toward the end of summer or early in fall because of the lack of perennial ice in this basin. Low flows during winter are usually less extreme because a smaller percentage of this basin is subject to freezing temperatures. Based on available data the estimated low flow for the South Fork at its confluence with the main river is 180 cubic feet per second.

Tributaries of the South Fork are for the most part small with the exception of Skookum Creek, which heads on the southwest slopes of Twin Sisters Mountain and discharges into the South Fork about four miles above Acme. Its short length of run combined with its relatively high and low elevations gives it one of the steepest gradients of the streams studied.

Although Skookum Creek appears to have its catchment area advantageously located to derive maximum benefits from precipitation, in reality its runoff is considerably less than might be expected. Close scrutinization shows that the main feature of the basin is a steep, narrow canyon which protects much of the lower valley from direct contact with storms. The only part with good orientation and exposure is the southwest slopes of Twin Sisters Mountain, which represents only a small percentage of the entire area. The overall result is that Skookum Creek produces an average of only 75 inches of runoff annually, while similarly located adjacent tributaries contribute amounts equal to or greater than 100 inches. In spite of this, the large watershed of Skookum Creek produces better than 90,000 acre-feet of annual runoff, which by far surpasses that of any other tributary in the South Fork basin.

The low flow estimate of 25 cubic feet per second for Skookum Creek is considered to be one of the more reliable figures in the streamflow evaluation table and represents an average of actual measurements taken over a period of 12 years. Although glaciers exist on Twin Sisters Mountain, Skookum Creek receives none of its low flow from this source as the entire ice area is situated on the north side of the mountain and drains into the Middle Fork system.

Hutchinson, Cavanaugh, and Howard Creeks are other tributaries worthy of mention, but each produces only about half as much runoff as Skookum Creek. Very little data was available to estimate low flows and annual runoff for these and other small tributaries in the South Fork basin.

Winter snowpacks that pile up in high altitudes represent the South Fork's main form of natural storage. Many small natural lakes are also found in this basin, but they add little to the total amount of storage. Reference is made to table 28 for more complete information on their location and size.

SMITH CREEK

Smith Creek is a small stream that starts near the summit of Sumas Mountain and flows in a southerly direction to the Nooksack River valley just west of the gap at Deming. Here it makes an abrupt turn to the northwest and parallels the Nooksack River, finally flowing into it just south of Lawrence.

Two distinct physiographic features are noted in this watershed. The upper portion, situated on Sumas Mountain, has a moderate slope near the source and gradually becomes steeper as the stream approaches the valley. This area at one time was heavily timbered but more recently has been logged off and now is covered by smaller second growth trees and brush. The lower part of the basin along the foot of the mountain is moderately flat with a gentle downstream slope toward the main Nooksack River.

Smith Creek drains an area of 10.6 square miles and its watershed includes elevations from 3,300 feet near the summit of Sumas Mountain to about 120 feet where it joins the Nooksack River. Squalicum Mountain and the range of mountains across the Nooksack River to the south have a tendency to block some of the effectiveness of oncoming storms, but this is offset somewhat by the favorable southwest exposure and high mean elevation of the basin, resulting in a moderately high annual precipitation.

No continuous streamflow records have been collected on Smith Creek, but based on a few miscellaneous measurements and runoff information from nearby watersheds, it is estimated that Smith Creek produces an average annual runoff of 29,000 acre-feet and experiences a low flow of about 0.3 of a cubic foot per second. Except for small amounts of snow, a few stagnant sloughs near the Nooksack River, and limited ground-water reservoir areas, there is very little natural or artificial storage in the basin.

ANDERSON CREEK

Originating near the crest of an unnamed mountain lying east of Squalicum and south of Sumas Mountains, Anderson Creek cascades down in a northwesterly direction over a falls and through a steep gorge, finally emerging at the eastern end of the King Mountain Upland. From here it makes a turn to the north and falls at a greatly reduced gradient until it reaches a large oxbow bend on the Nooksack River about four miles away. Along its course of travel it is joined by a few small intermittent drainage courses, but in reality, it has only one significant tributary. This is an unnamed branch that feeds into it from the south as the main stream enters a broad valley immediately east of Squalicum Mountain.

Anderson Creek has a total drainage area of 14.3 square miles and contains elevations that range from 115 feet to 3,080 feet above sea level. Topographically, terrain along the upper reaches greatly resembles that of Sumas Mountain and, in a like manner, most of the area has been logged off and is now covered with slash and second growth. Some farming is carried out in the lower part of the basin, but similar to the upper areas, second growth represents the most prevalent type of foliage.

No actual measured precipitation data are available from within this watershed, but the mean annual values of 56 inches at Deming and 46 inches at Clearbrook probably are somewhat indicative of amounts received in the lowland region. Precipitation on the basin's upper half in all probability is considerably higher, but owing to its northwest exposure and the presence of Squalicum Mountain, quantities here should be somewhat less than those experienced by areas of like elevation on Sumas Mountain.

Continuous streamflow records were obtained during two summer seasons on Anderson Creek near the settlement of Goshen and are of some value in estimating its low flow characteristics, but they are of too short a duration to be of much value in determining the total average annual runoff. A value of 36 inches or 27,800 acre-feet was, therefore, estimated with the aid of hydrologic relationships and measured quantities from similar nearby watersheds.

Other than one or two small isolated swamp areas near the stream's headwaters, no surface storage of consequence exists in the basin. Much of the lower area geology is comprised of readily drained recessional outwash material, which, when combined with the meager amount of surface storage, produces extremely low flows during critical summer months.

STICKNEY SLOUGH

The two major tributaries of Stickney Slough, Mormon Ditch and Kamm Ditch, originate in an area of hilly parallel ridges about three miles east of Lynden and from there flow in westerly and southwesterly directions respectively until they reach a swampy area about one mile east of Lynden. Here they join to form Stickney Slough which continues on to the west as far as the city limits of Lynden and then turns south, flowing for about half a mile through an abandoned oxbow depression, to the Nooksack River. Contrary to other basins thus far discussed, the terrain and most soils in this and surrounding areas are excellent from an agricultural standpoint, but a generally high water table makes it necessary to drain the land before it can be effectively farmed.

The eight square mile watershed of this system contains very low elevations, ranging from 40 to 140 feet above mean sea level, indicating that orographic influence has very little effect on precipitation falling on the basin. Climatalogical data obtained nearby at Clearbrook shows a total mean annual precipitation of nearly 46 inches, but considering values at other stations in the vicinity, mean annual precipitation on the Stickney Slough basin is probably a little less.

Although streamflow data is limited to a few spot measurements, one can imply from the high water table condition and numerous springs, that streamflow in this basin is quite stable throughout the year. Based on precipitation, evapotranspiration, and streamflow data obtained in nearby areas, the mean annual runoff from the Stickney Slough watershed was estimated to be 9,200 acre-feet or about 22 inches over the basin, and because of the large ground-water contribution, its flow should seldom recede below 5 cubic feet per second. Although both aforementioned tributaries receive most of their flow from ground water effluent, Kamm Ditch also receives a large amount from several large springs located near the escarpment at the edge of the Lynden Terrace. This branch drains more than half of the total basin and by far contributes the most significant amount of runoff.

Other than swamp land, the Stickney Slough region has practically no surface-water storage. Natural storage in the form of snow is negligible because of generally warm temperatures, and only one small spring pond located immediately east of Lynden exists in the area.

SCOTT DITCH

Scott Ditch originates just west of Strandell and flows nearly due west for about five miles until it reaches the

Nooksack River just above the Guide Meridian Highway bridge. Approximately half-way along its course it is joined from the south by Elder Ditch, the outlet stream of Fountain Lake. Bellingar Ditch, an intermittent cross connection into the Wiser Lake Creek drainage, joins Scott Ditch a short distance farther downstream. All remaining tributaries in this network are rather insignificant and consist primarily of small individual farm drainages.

A large percentage of this stream's flow is derived from springs in the hilly area just south of Strandell. Although not entirely obvious, these springs probably originate from the outflow of Lake Fazon, which lies about three miles farther south. During periods of high rainfall, overflow from this lake drains for about a mile along a course to the north and then suddenly stops and ponds in a densely wooded area. Here sizeable quantities of water obviously filter into the ground as there is no apparent surface outlet,and most likely, most of this recharges the springs above Strandell.

All of the 9.8 square miles in the Scott Ditch watershed are mantled by the rich alluvium found in the Nooksack Lowlands, and like the Stickney Slough area, this soil is excellent for farming when the water table is controlled by proper drainage methods. The region between Scott Ditch and the Nooksack River levee is relatively flat, but farther south the land begins to rise somewhat reaching a maximum elevation of about 125 feet. This extremely low relief exerts little influence on passing air masses, and from records taken at nearby stations, precipitation on an average varies from about 30 inches in the western portion of the basin to 40 inches in the east.

An estimated annual runoff of 9,700 acre-feet or 20 inches of water over the basin is based mainly on records obtained in surrounding areas. Like other primarily ground-water fed streams, Scott Ditch has a rather consistent flow pattern throughout the year, but discharge is higher than normal during late fall and winter and at its lowest in August and September. Miscellaneous measurements taken near the stream's confluence with the Nooksack River substantiate this trend and indicate an average minimum discharge of about 4 cubic feet per second. There is little natural surface storage in this watershed except for some water in Fountain Lake at the source of Elder Ditch.

FISHTRAP CREEK

Fishtrap Creek and its neighbor to the west, Bertrand Creek, differ from all other streams in the report area because more than half of their watersheds lie across the border in Canada. Small headwater tributaries of Fishtrap Creek start in Canada in two perched marshy areas and thereafter combine to form the main stem, which then continues on in a southwesterly direction into the United States, picking up other tributaries from the north along its way until it reaches the Nooksack River about three miles southwest of Lynden. Except for a few high mounds near the source, the major topographic feature of the basin is a nearly flat plain that slopes gently to the south. This flat area encompasses most of the Lynden Terrace and consists primarily of permeable glacial outwash material, while the higher areas are covered by relatively watertight glacial till or hardpan, creating swampy perched water-table conditions. In addition to the above deposits, a small portion of the basin southwest of Lynden lies in recent alluvial deposits characteristic of the Nooksack lowlands.

It is difficult to accurately determine the exact amount of surface area drained by a flat basin such as this, but recent large scale topographic maps indicate the total watershed of Fishtrap Creek to be about 30.6 square miles and the drainage area contributing to Stream Gage No. 2120 to be 16.3 square miles. In comparison, this latter figure appears in older U. S. Geological Survey publications as 24.1 square miles, but was based on maps printed in 1908.

Elevations within the basin vary from about 25 feet near the stream's confluence with the Nooksack River to about 475 feet in Canada near the headwaters. This moderate relief has little orographic influence on moving air masses, but there is a general tendency for precipitation on the lowlands to increase as one approaches the high mountains north and east of the Whatcom Basin. For example, an average annual precipitation of 46 inches has been recorded at Clearbrook while Canadian stations to the north and east at Abbotsford and Chilliwack have recorded 63 and 64 inches of precipitation respectively. Unfortunately there are no precipitation data from within Fishtrap Creek basin itself, but it appears from the neighboring stations that this region receives an average of about 46 inches per year.

Fishtrap Creek has several years of continuous streamflow record and this provides the best indicator of runoff quantities in the lower basin. Nearly 28 inches of water runs off annually from the area above this gage and the estimated runoff for the entire basin is about 26 inches or 43,000 acre-feet. Fishtrap Creek receives a major portion of its flow from ground-water runoff, but during periods of intense precipitation, the streamflow hydrograph also shows peaks characteristic of direct surface runoff. Throughout dry periods in summer the sizable ground-water contribution adequately maintains flow and it is estimated that the low flow of the stream where it enters the Nooksack River should seldom be less than 10 cubic feet per second.

A series of parallel north-south ditches situated between Lynden and the Canadian border at half-mile intervals make up the major tributary system of this stream. This intricate drainage network was developed to improve the land for farming by lowering the high water table that existed in the region. Of all the tributaries, Double Ditch is largest, originating in Canada from the same marshy area that is the source of Fishtrap Creek and joining the main stream just below Lynden. Double Ditch aquired its name from the fact that it is divided at the international border and then flows in the ditches along both sides of Double Ditch Road. About half a mile below the border, the west branch of Double Ditch divides once more and about one cubic foot per second of its flow is diverted into Bertrand Creek basin. The three remaining major tributaries, Benson, Depot, and Bender Ditches located at half-mile intervals in that order to the east of Double Ditch, are all considerably shorter and do not extend appreciably into Canada. Based primarily on its percentage of the total area, Double Ditch contributes roughly one-eighth of Fishtrap Creek's total runoff and the combined flow of the other three major tributaries provides about one-fifth of the total.

Like other streams in the area discussed previously, surface storage is practically non-existent in Fishtrap Creek basin and the small amounts present are confined to the marshy areas in Canada. Much of this area, however, has been recently ditched and reclaimed for use as farm land. These improvements have resulted in a general increase in flows farther downstream and at times the additional discharge has caused the capacity of certain ditches on the American side to be exceeded. Laxton and Judson Lakes near the border store sizable volumes of water, but they are isolated and appear to have no direct surface outlet into this or any other drainage system. There is evidence, however, that Laxton Lake may contribute to Fishtrap Creek and Judson Lake to Pangborn Creek by subsurface means, and this in effect would create additional storage in the area.

BERTRAND CREEK

The area drained by Bertrand Creek lies adjacent to and west of Fishtrap Creek basin and extends as far into Canada. Small intermittent upstream tributaries start near Aldergrove in the lower, eastern part of the Boundary Upland and flow west for about three miles paralleling the Trans-Canada Highway. The main stream then turns south near swamp lands at the headwaters of Campbell Creek and continues on in this general direction into the State of Washington. About a mile south of the border it emerges from the Boundary Upland hills and flows out onto the western part of the Lynden Terrace. After meandering over this shelf for about five miles, the stream drops into the Nooksack Lowlands and shortly thereafter reaches the river about a half mile below the point where Fishtrap Creek empties into the Nooksack River.

Bertrand Creek basin has a drainage area of 43.5 square miles and contains elevations ranging from 25 feet in the south to 450 feet in the north. Precipitation is not recorded within the basin itself, but as indicated by nearby stations, it appears to increase with higher elevations. The upper portion of the watershed is situated about midway between Langley Prairie and Abbotsford, and these stations record mean annual precipitation of 60 and 63 inches respectively. There are no stations in or near the lower half of the basin, but judging from records at Blaine, Bellingham, and Clearbrook, this region receives around 40 inches per year.

A geological comparison of the Bertrand and Fishtrap Creek watersheds indicates that less precipitation infiltrates in the Bertrand Creek basin because more of the area is capped with the impervious Boundary Upland glacial till. As a result, this watershed produces more direct surface runoff and less ground-water runoff than Fishtrap Creek basin. During dry periods the lack of ground water causes tributaries on the Boundary Upland to recede rapidly to very low flows, but farther south in the glacial outwash region, increasing ground-water inflow makes streamflow more uniform and reliable.

Tables 2 and 3 show that basic streamflow data in the basin is comprised of several scattered miscellaneous measurements and two periods of seasonal record on the main stem. It is difficult to draw meaningful conclusions about total annual runoff from short duration records such as these, so data from Fishtrap and Dakota Creeks were also employed in the analysis. The results of this study are listed in table 27 and show that Bertrand Creek basin produces a mean annual runoff of about 24 inches or 56,000 acre-feet. Using data described above, the low flow of this stream system just prior to its junction with the Nooksack River is about 9 cubic feet per second.

Most tributaries to this stream flow in natural channels in their upper reaches, but ditching and drainage improvements have been undertaken in the lower basin to reduce soil moisture and improve farming. At one time East Guide Meridian Ditch flowed into Fishtrap Creek about a mile west of Lynden, but more recently this ditch has been diverted to prevent excessive flooding in the area and now joins Bertrand Creek by way of Duffner Ditch near the lower end. West Guide Meridian Ditch, which receives additional flow from the west branch of Double Ditch, has also been diverted into Bertrand Creek, but it enters about three miles farther upstream. The watershed of Van Ditch lies mainly in Canada, and because of its size and location, this tributary most likely produces a greater runoff than any of the others. The Duffner Ditch drainage area is next in size followed by the watershed of the unnamed stream north of confluence no. 13:2, but both are of equal importance as far as total runoff is concerned.

Little natural surface storage exists in the watershed other than that found in one or two small marsh areas and several small lakes and ponds. The most significant of these are the 3.5 acre lake on the unnamed tributary just north of stream confluence number 13:2 and a smaller pond half a mile north of the Blaine-Sumas Road on McClelland Creek.

SCHNEIDER DITCH

Schneider Ditch is a small stream but worthy of discussion because its waters are quite heavily appropriated, and it is located in an extensive agricultural area. Tributary headwater ditches of this stream start in a marshy area near the center of the Custer Trough and feed into the main channel which flows in a general southeasterly direction. About a quarter of a mile from the Nooksack River it makes an abrupt turn south and flows into Keefe Lake. Flow from the outlet of this lake then discharges into the river a short distance away. The Schneider Ditch watershed, lying in part of the relatively low Custer Trough and Nooksack Lowlands, is underlain with porous and permeable alluvium and glacial outwash material suitable for storing sizeable quantities of ground water. This ground-water reserve sustains the flow of Schneider Ditch during dry periods and provides much of its total annual runoff.

The surface area of this basin is approximately 5.1 square miles, and elevations range from about 15 feet to 75 feet above mean sea level. The area lies in the lee of the Mountain View Upland and this, combined with low elevations, reduces its ability to intercept precipitation. No climatological data is available in the watershed, but precipitation is estimated to average about 30 to 35 inches per year.

Based primarily on measurements of nearby streams, Schneider Ditch should experience an average annual runoff of about 15 inches or 4,100 acre-feet and an annual low flow of about one half a cubic foot per second.

Surface water in the basin is stored primarily in two lakes. Willey Lake in the northern part is isolated without an outlet, but based on topography, it lies within the Schneider Ditch drainage area. Keefe Lake, mentioned previously, is in the southern part of the basin and is merely an elongated enlargement of Schneider Ditch.

WISER LAKE CREEK

Wiser Lake Creek, or Cougar Creek as it is sometimes called, drains a narrow, poorly-defined area lying between the Scott Ditch and Tenmile Creek systems. The portion above Wiser Lake, called Bellingar Ditch, connects with Scott Ditch during high water periods, but its usual direction of flow is toward the west. Wiser Lake itself covers an area of 123 acres and lies on both sides of the Guide Meridian Road about one mile south of the Nooksack River. Its outlet, Wiser Lake Creek, flows from the west end of the lake in a southwesterly direction for approximately three miles and finally reaches the Nooksack River about three miles above Ferndale. Other than the main stream, there are only two tributary water courses of importance in this system. One originates from a spring and flows for about a mile discharging into the head end of Wiser Lake, and the other starts in the West Ditch along Aldrich Road and flows due north for nearly a mile to Wiser Lake Creek.

As shown on the Geologic Map (pl. 1), recessional outwash deposits and a small amount of alluvium near the lower end of the basin make up the surface geology of this area. In contrast to the featureless terrain of the Lynden Terrace, this watershed is quite hilly and irregular, ranging in elevation from 15 to 100 feet above mean sea level.

Basic streamflow data for this system consist of only a few miscellaneous measurements; consequently, all estimates presented in table 27 were developed from general relationships applicable in the lower part of the report area. The mean annual runoff and low flow found for the stream was about 15 inches or 5,800 acre-feet and 1.8 cubic feet per second respectively. As in most other small low elevation basins, the distribution of precipitation producing this runoff should be quite uniform and is estimated to average around 35 inches per year.

Wiser Lake, having a relatively large area, provides ample storage and regulates roughly one-half the runoff from this basin. An enlargement of Wiser Lake Creek near its confluence with the Nooksack River also furnishes a certain amount of water retention, but the amount is small in comparison to that provided by Wiser Lake.

TENMILE CREEK

Tenmile Creek and its two major tributaries, Fourmile and Deer Creeks, drain a major portion of the Whatcom Basin lying south of the Nooksack River and extending nearly to the towns of Strandell and Goshen in the east and Ferndale in the west. The small headwater tributaries of Tenmile Creek start in the eastern part of the King Mountain Upland just south of Fazon Lake and join to form the main stem which in turn flows in a northwesterly direction through a narrow gorge until it approaches the settlement of Tenmile. Here it describes an arc to the southwest picking up Fourmile Creek just past the Guide Meridian Road. After bearing in this general direction for nearly three miles, the main stream enters Barrett Lake. This mile-long marshy enlargement of the stream is actually an artificial reservoir caused by a beaver dam at the lower end. Deer Creek, the other main tributary, joins the drainage system from the southeast near the midpoint of Barrett Lake. About half a mile beyond Barrett Lake and just above the U. S. Highway 99 bridge at Ferndale, Tenmile Creek ultimately flows into the Nooksack River.

Most higher elevation land lying in the southeastern half of the basin is an extension of the King Mountain Upland being composed primarily of glacial till or "hardpan" with a few outcrops of older tertiary sediments. This area is less fit for farming than the remaining northwest part of the basin, and a good share of it is forested mainly with second growth deciduous trees. Large portions of the upstream bottom land in this area and the entire northwestern half of the basin are covered with the same type of pervious glacial outwash material found in most other parts of the Nooksack Lowlands. Fourmile Creek and lower reaches of Tenmile and Deer Creeks flow in this section of the basin, and as indicated previously, this flatter terrain is excellent for agriculture. The watershed extends over an area of about 34.0 square miles, and exhibits elevations between 10 and 370 feet above mean sea level.

There are no high, abrupt obstructions within the area to produce an orographic effect on atmospheric flow; consequently, precipitation over the basin is probably quite uniform. Climatological data have never been collected within this basin, but using information obtained at Bellingham, Deming, and Clearbrook, it appears that total precipitation in any average year amounts to about 30 inches near the western end of the basin to 40 inches in the eastern part.

Despite the magnitude and importance of this watershed, streamflow data are limited to two summer seasons of continuous record and a few miscellaneous measurements taken at various locations. Using these data in conjunction with other records from nearby streams, the estimated total annual runoff for Tenmile Creek is 18 inches or 33,400 acre-feet, and the annual low flow, 5 cubic feet per second.

As mentioned in the discussion of Scott Ditch, Fazon Lake lies in the surface drainage area of the Fourmile Creek system. In reality, however, flow from its outlet ponds and disappears into the ground near the poorly-defined divide between these two watersheds, and until a thorough investigation is made, it must be assumed that a portion of the water drains into both basins. This subterranean flow apparently shows up in seepage springs above Strandell in the Scott Ditch drainage, and it is also quite possible that it contributes to the ditches above Green Lake that flow into Fourmile Creek.

The above two lakes and Barrett Lake provide most of the useable surface storage in the Tenmile Creek watershed. Some use is presently being made of waters in all three of these lakes, but their supplies still remain practically undeveloped; consequently, they should furnish ideal sources for future needs. Other information about these lakes can be obtained from table 28. In addition to these main sources, smaller quantities of water are also stored artificially in farm ponds and ditches.

DAKOTA CREEK

Dakota Creek, situated in the far northwestern corner of the report area, is one of four major streams along the coast independent of the Nooksack River drainage system. The North Fork, its major branch, originates about half a mile south of the international border near the summit of the Boundary Uplands and from there flows southwesterly into the Custer Trough to a point about two miles north of Custer where it joins the smaller South Fork. The South Fork's source is near Bertrand Creek at the eastern end of the trough, and its main stem flows with very little deviation in a northwesterly direction to the North Fork confluence. From here Dakota Creek proper continues in the same northwesterly direction, picking up several large tributaries from the north along its course and eventually discharges into Drayton Harbor just south of Blaine.

This drainage system covers 28.3 square miles and extends a short distance into Canada, but not nearly as far as the basins of Bertrand and Fishtrap Creeks. Elevations vary from sea level to about 540 feet and this moderate difference, combined with the east-west orientation of the uplands, produces some orographic precipitation on the watershed. Blaine receives only 39 inches annually, but to the north and farther inland, stations at Langley Prairie and Aldergrove report 58 and 62 inches respectively. The latter two stations are situated considerably lower than the highest elevations found in the Boundary Upland and it would, therefore, be reasonable to expect at least equal and possibly greater amounts in the northern part of Dakota Creek basin. The Custer Trough portion, being much lower and partially in the lee of the Mountain View Upland, in all probability receives precipitation in amounts comparable to or less than that of Blaine. A little more than five years of streamflow record were obtained on Dakota Creek from that part of the basin contributing flow above Haynie Road. This road crosses the main stem more than three miles upstream from the mouth, and as a result, nearly one-half of the total runoff was never measured because it entered below the gage site.

It is impossible to obtain complete coverage by a single gage in streams like this, however, as measurements taken farther downstream would be affected by tidal action. Using these records and information provided by miscellaneous measurements on the major tributaries, the mean annual runoff and low flow estimated for Dakota Creek at its mouth is 23 inches or 34,400 acre-feet and about 3 cubic feet per second. Like Bertrand Creek many smaller tributaries in the upland regions become dry in summer, and though baseflow is maintained quite well in the Custer Trough farming area, large appropriations here obviously have an adverse effect on low flows.

The old five million gallon reservoir used in the past by the city of Blaine for their water supply and a few small farm ponds contain most of the surface storage in this basin. As in the rest of Whatcom Basin, only about 3 to 4 percent of the total precipitation falls as snow and this is very short-lived providing no useful storage.

CALIFORNIA CREEK

California Creek, like Dakota Creek, flows nearly northwest and discharges directly into Drayton Harbor. Most headwater tributaries on the southwest side of the basin flow from the summit of the Mountain View Upland to the main stream near the base of these hills, while a complex interconnecting system of ditches drains part of the Custer Trough on the opposite side of the basin.

The watershed of California Creek covers about 22.8 square miles and elevations within the area range from sea level to over 360 feet. A slight rain shadow is produced by the Mountain View Uplands over the lowland part of this basin, and as a result, it receives somewhat less total precipitation than the two adjacent basins to the north and south. Following the precipitation trend, runoff is also reduced somewhat and overall is estimated to be about 15 inches or 18,000 acre-feet annually. Low flows, however, as indicated by one seasonal record and several miscellaneous measurements, are not as severely affected by the lower precipitation and should average approximately 1.5 cubic feet per second at the mouth.

Some time ago efforts were made to drain most of the original marsh land and improve it for farming, so at present the only useable storage in the area is contained in a few small lakes and ponds.

TERRELL CREEK

Terrell Creek and its tributaries drain an irregular-shaped section of the Mountain View Upland situated roughly between the settlement of Mountain View and Birch Bay. For all practical purposes, the source of this stream is Terrell Lake. Flow from this large, marshy body of water is controlled by a small dam at its outlet, and the quantity spilled has considerable influence on total flows farther downstream. From the lake outlet, the stream meanders in a northwesterly direction, and after about two miles, is joined by Fingalson Creek from the east. Shortly thereafter the main stem turns west and flows as far as Point Whitehorn Road on the shore of Birch Bay. Here it again turns abruptly and runs parallel with this road in a northeasterly direction for about two miles to its mouth in Birch Bay.

Except for a few isolated patches, this basin is capped with hardpan, making ground water very scarce. As a result, nearly all streamflow is derived from surface runoff while baseflow is practically non-existent. Miscellaneous measurements taken in the region substantiate this and show that the streams dry up completely every summer.

The terrain, like that exhibited in California Creek basin, varies in elevation from sea level to over 360 feet, but in this case the mean basin elevation is somewhat higher and the entire area unobstructed to the southwest resulting in greater amounts of precipitation and runoff from certain portions of the watershed. Terrell Creek is completely void of useable hydrologic data, and one can only infer from similar nearby areas the quantities that can be expected here. Considering all available relationships and information, precipitation should average between 30 and 35 inches and mean annual runoff from the watershed should be about 15 inches or 14,000 acre-feet.

Terrell Lake, which has the largest surface area of any lake included in the report, retains a sizable percentage of the annual runoff and helps to regulate downstream discharges during the dry summer seaon. Low flows are also aided by the fact that little use is made of the surface waters in this basin except for two diversions from small reservoirs near the lower end.

LUMMI RIVER

Prior to 1860 the Nooksack River discharged into Lummi Bay by way of the channel presently used by the Lummi River. During that year a log jam blocked the Nooksack River and diverted it to a small stream that flowed into Bellingham Bay and since then the stream remaining in the Nooksack River's old channel has been called the Lummi or Red River.

For all practical purposes, the Lummi River has only two major tributaries, but a maze of independent small streams and ditches also flow into its complex delta region. In addition to these tributaries, a continuous supply of fresh water is diverted into the Lummi River proper from the Nooksack River by means of an interconnecting culvert; consequently, the Lummi River is actually a distributary of the main river. It would be comparatively easy to measure this incoming amount, but nearly impossible to determine the total output at the lower end of the Lummi River owing to the complex tidal action that takes place there. No attempt was, therefore, made to analyze the main stem itself, but instead, all efforts were concentrated on the major tributaries, which are either situated above high tide level or sealed off from this action by flap gates and dikes. In general, these streams drain the Mountain View Upland's southeastern slopes, and because ground water is lacking, most of them become completely dry during summer seasons. On the other hand, in lower areas of recessional outwash and alluvium, ground water is abundant and stream channels remain completely filled throughout the year.

Individual estimated amounts of mean annual runoff produced by each important tributary are listed in the evaluation table, but in general, an average for the area is around 17 inches. Precipitation data collected at Marietta, a few miles to the southeast, indicates that an average of 30 inches per year falls on the delta region, but if upland tributary areas are included, this figure should be an inch or two more. As indicated above, a considerable amount of water is stored in the lowland sloughs and ditches, but this water is rather stagnant and, though it has not been sampled for quality, is probably quite brackish.

SILVER CREEK

Silver Creek and its major tributaries, Bear Creek, Andreason Ditch, and Tennant Lake Creek, drain a small watershed just northeast of the Nooksack Delta and northwest of Bellingham. Its headwaters originate on northwest slopes of the King Mountain Upland and gradually turn to the southwest into the Nooksack River's alluvial trough. After passing through an extensive marshy region in the trough, the stream empties into Bellingham Bay near the town of Marietta.

The basin occupies 15.8 square miles and contains terrain ranging in elevation from sea level to about 350 feet. This moderate relief does not have an appreciable effect on precipitation, but some variation is evident as indicated by gages at Marietta and the Bellingham Agricultural Experiment Station. These gages are situated about four miles apart, and in this short distance mean annual precipiation varies from nearly 30 inches to about 32.5 inches. Based on these quantities of precipitation and various streamflow records, the mean annual runoff for Silver Creek was estimated to be about 14 inches, or an equivalent total volume of 11,500 acre-feet.

Like streams originating on the Mountain View Upland, very little ground water is present to feed the upper tributaries in this system, and as a result, many of them dry up during summer months. Larabee Springs on the divide between the Fourmile Creek watershed and this basin flows into both drainages and by itself sustains most of the flow in the main stream during dry periods. Other than a few marshes, Brennen Pond and Tennant Lake furnish most of the surface storage for the system, and these bodies of water together with contributions from ground water help to amplify low flows along lower reaches of this stream.

SUMAS RIVER

Sumas River basin is an important agricultural area situated in the transition region between the Whatcom Basin and Cascade Mountains. Sumas Mountain occupies the high eastern half of the watershed and Sumas Trough the low western part containing elevations just slightly above mean sea level. With the exception of the Johnson Creek system, all major tributaries originate near the summit of Sumas Mountain and descend abruptly to the west onto the lowland where they are intercepted by the main stem. The river itself starts on the southwest side of the mountain and, after cascading to the lowland, turns sharply and flows in a northerly direction along the base of the mountain. In this reach, the stream is located less than half a mile from the Nooksack River, and in past years, flood waters of the Nooksack River have spilled over this low narrow divide into the Sumas Valley. From here the stream meanders northward away from the Nooksack River, and past the city of Nooksack, it turns northeast toward the city of Sumas. Johnson Creek, which drains the northwestern part of the Sumas Trough and part of the Lynden Terrace, joins the river just east of Sumas and from there the main river crosses the border and flows in a northeasterly direction into the Vedder Canal near its confluence with the Fraser River.

In the Canadian portion of the Sumas Trough elevations are exceedingly low with some areas actually being below sea level. Dikes were, therefore, necessary to confine the river in this region to prevent it from flooding the low valley and a dam was constructed near the lower end to keep the Vedder from backing up into the channel of the Sumas. Also, at times when the stage of the Vedder and Fraser are higher than the Sumas, it becomes necessary to pump water from the Sumas over this dam to prevent it from backing up and spilling over the dikes.

Except for a small strip of hardpan along the base of Sumas Mountain, most of the material in the Sumas valley consists of recessional outwash and recently deposited river alluvium. The ground-water supply map (pl. 3) indicates that these latter mentioned deposits are quite highly productive; therefore, streams toward the lower end of the basin receive a considerable contribution from ground water and exhibit sizable baseflows. As a result of the relative positioning of these lowland deposits, several tributary streams flow down from the mountain and cross the strip of hardpan but disappear into the ground when outwash is reached.

The total area contributing flow to the Sumas River where it crosses the United States-Canadian border is 55.8 square miles, of which the Johnson Creek portion is 20.7 square miles. Portions of these above areas are situated in Canada and they produce runoff that drains into the United States and then returns to Canada by way of the Sumas River. Also, the above figures do not include the entire Sumas basin area on the United States side of the border because a small part of this drains across the border and reaches the river on the Canadian side.

Elevations range from about 30 feet at the lower end of the Sumas Trough to more than 3,300 feet on top of Sumas Mountain. Although this difference in elevation is only moderate in comparison to other parts of the report area, no major obstructions exist to the west, and as a result, passing air masses receive most of their initial orographic lift from Sumas Mountain, causing large quantities of vaporized moisture to condense and precipitate out in the process. Unfortunately, there are no records to prove just how much precipitation actually falls at various places on this mountain, but based on experiments in other regions and measured streamflow quantities, it can be inferred that the annual average precipitation around the summit should be near 100 inches. Clearbrook lies in the middle of the lower basin, and its average annual precipitation of 46 inches should be fairly representative of most of the lowland area.

A multitude of miscellaneous streamflow measurements have been taken in this region and, combined with four seasonal records on the main river, provide a fairly reliable basis upon which to estimate minimum flows. Based on this information, the average low flow of the Sumas River to be expected at the border should be about 25 cubic feet per second, and of this, Johnson Creek would probably contribute about 12 cubic feet per second. Two complete years of continuous streamflow data are available on this stream, and using these in conjunction with more reliable records from nearby streams as a control, the total mean annual runoff of the Sumas River where it crosses the border was estimated to be about 91,000 acre-feet or an equivalent of 31 inches of water over the entire watershed above this point. Continuous streamflow data have never been collected on Johnson Creek, but it is estimated that this tributary contributes a little less than one-third of the above total.

In a prior section it was mentioned that Judson and Laxton Lakes near the border appear topographically to be independent of this drainage basin, but several springs lie just southwest of Judson Lake and it seems quite possible that their flow originates from this source. Pangborn Lake, a shallow marshy body of water about a mile southwest of Judson Lake, gets some of its water from these springs and represents the only surface storage actually within the Sumas River drainage system.

SAAR CREEK

Saar Creek originates in Paradise Valley on the north side of Sumas Mountain and flows north for about three miles to the pass between Sumas and Vedder Mountains. Here it turns west, and after a mile or so, drops into the Sumas Trough. Once in the lowland, it flows northeasterly across the trough and joins the Sumas River about three miles north of the international border in Canada. Mud Slough, its major tributary, starts in Anderson Lake near the southwest end of Vedder Mountain and from there flows onto the lowland joining Saar Creek in Canada by way of Arnold Slough.

When the glaciers receded, sizable deposits were left behind to mantle Paradise Valley. This material being quite permeable and porous has a sizable ground-water storage capacity, and as a result, there are many marshy springs in the area which help to maintain flow during dry periods. Farther down in the pass between the two mountains, the stream's banks have been diked to alleviate flooding and in this reach little ground water is contributed to the total flow. In the Sumas Trough the gradient flattens out and once more its flow is increased by ground water stored in the alluvium.

Based on miscellaneous measurements and two summer seasons of continuous streamflow record taken at two different locations on this stream, the average low flow was estimated to be about 0.2 of a cubic foot per second. Annual runoff has never been measured on this stream, but by extending relationships from nearby basins, the mean annual runoff is estimated to be about 22,000 acre-feet or 41 inches.

FLOODS IN THE NOOKSACK RIVER BASIN

(By E. G. Bailey, U. S. Geological Survey)

Floods generally result from acts of nature and cannot be eliminated. However, within limits of economic feasibility, they can be controlled by reducing their destructive forces or by providing protection against them. A flood is defined as a condition that prevails when the waters of a stream exceed the capacity of the channel and overflow the adjacent flood plains.

HISTORY OF FLOODS

There is relatively little recorded information on the occurrence of floods in the Nooksack River basin. The principal source of information about floods during the early days of settlement by white men is from accounts of the pioneers of the region, of whom a few are still alive. Newspaper accounts and records from the railroads, during the early years of the 20th century, also serve as sources of information prior to the beginning of systematic stream gaging in the area.

In a field investigation by the U. S. Geological Survey the earliest evidence found of a major flood in the Nooksack River basin refers to a flood that occurred "about 1893." There is reason to believe that the year was 1894 because the flooding in this basin in that year would have been concurrent with major floods in many other river basins of the region.

Other notable destructive floods on the Nooksack River are reported to have occurred in 1909, 1917, 1921, 1932, and 1935. Few data have been found that can be used for computing peak discharges for these floods. However, comparison of the available information with the records of nearby rivers indicates that the flood of 1909 on the Nooksack River had the greatest magnitude of any flood since the valley was settled.

Correlation of known floods on this river with those in adjacent basins brings forth interesting speculation in regard to the occurrence of earlier floods than those now identified. Studies by Stewart and Bodhaine 1/ of floods in the Skagit River basin, based on Indian accounts, high-water marks, and other physical evidence, provide authentic information on major floods in that basin as early as about 1815 and indicate that the flood of 1815 had a higher peak discharge than any flood that has occurred since. Records of runoff in the Northwest coastal region show that floods in one basin usually are paralleled by excessively high flows in adjacent basins even though the relative magnitude of peak flows varies to some extent from basin to basin. Thus, floods of outstanding magnitude may have occurred in the Nooksack River basin in about 1815 and 1856, and were probably higher than any occurring since, including the flood of 1909.

Records of stage and discharge have been collected at various points on the Nooksack River since October 1933. From this date until 1959 the flood of greatest magnitude was that of February 10, 1951. The peak discharge at that time was 43,200 cubic feet per second at the Deming gaging station. From eye-witness account there is reason to believe that the peak discharge of the 1909 flood exceeded that of 1951.

The annual peak discharges of the Nooksack River at the Deming gaging station from 1936 to 1959 are listed in table 29; their lack of regularity may be seen by inspecting figure 50. The magnitude and frequency of floods are discussed in more detail in the following pages.

ORIGIN AND CHARACTER OF FLOODS

Floods in the area of the report occur during the fall, winter, and spring seasons. The fall and winter floods result primarily from rainfall sometimes augmented by snowmelt; whereas, spring floods usually result from snowmelt frequently supplemented by warm spring rains. Winter floods are characterized by peaks of relatively high magnitude and short duration. Almost without exception the most destructive floods in this region are of this type. Spring floods almost always have rounded peaks of longer duration.

The highest momentary peak discharge in a water year has been used as the significant flood characteristic for analysis in this report. Hereafter this peak discharge will be referred to as the "annual flood," although not every yearly peak discharge is of flood proportion. Also, the term "annual flood" does not imply that there may be only one flood of major importance each year; other peak flows occurring within

1/ Stewart, J. E., and Bodhaine, G. L., 1960, Floods in the Skagit River basin: U. S. Geol. Survey Water-Supply Paper 1527 (in press).

Table 29. Momentary maximum discharge, in cubic feet per second, of Nooksack River at Deming.

Water year	Maximum discharge	Date	Water year	Maximum discharge	Date
1936	12,100	May 4, 1937	1948	31,400	Oct. 19, 1947
1937	20,100	Dec. 22, 1936	1949	(c)	Feb. 17, 1949
1938	33,200	Oct. 28, 1937	1950	36,500	Nov. 27, 1949
1939	23,000	Jan. 1, 1939	1951	43,200	Feb. 10, 1951
1940	14,200	Dec. 15, 1939	1952	14,200	Jan. 30, 1952
1941	15,000	Jan. 18, 1941	1953	22,700	Jan. 31, 1953
1942	15,800	(a)	1954	24,900	Oct. 31, 1953
1943	17,200	Jan. 15, 1943	1955	23,300	Nov. 19, 1954
1944	23,300	Dec. 3, 1943	1956	38,500	Nov. 3, 1955
1945	28,800	Jan. 7, 1945	1957	27,500	Oct. 20, 1956
1946	38,000	(b)	1958	22,000	Jan. 16, 1958
1947	29,900	Oct. 25, 1946	1959	31,100	Apr. 15, 1959

a Dec. 2, 1941 and June 15, 1942.
b About Oct. 25, 1945
c Maximum discharge not determined; maximum discharge at the Lynden station was 17,500 cfs.

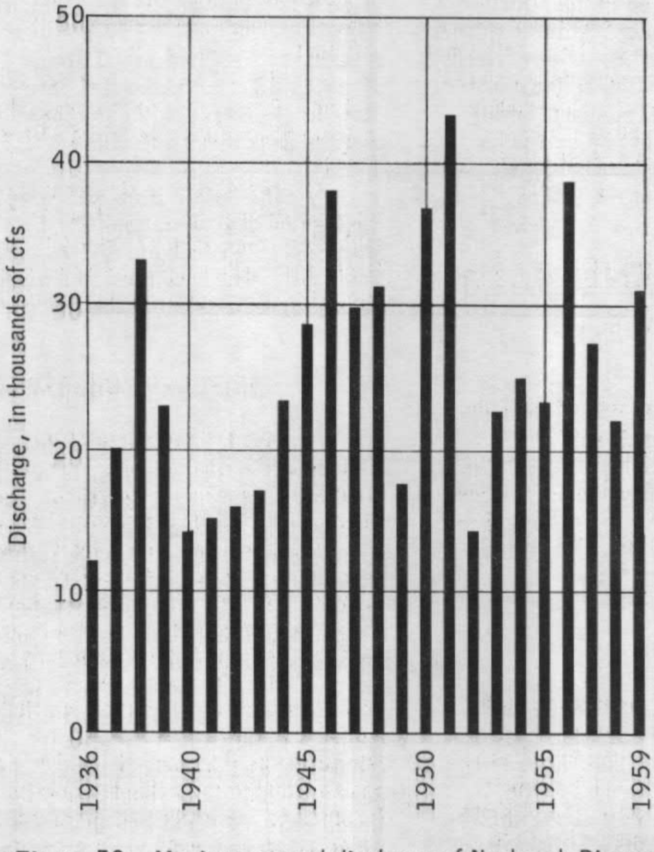


Figure 50. Maximum annual discharge of Nooksack River at Deming during the years 1936-59.

Figure 51. Magnitude and recurrence interval of annual floods, Nooksack River at Deming

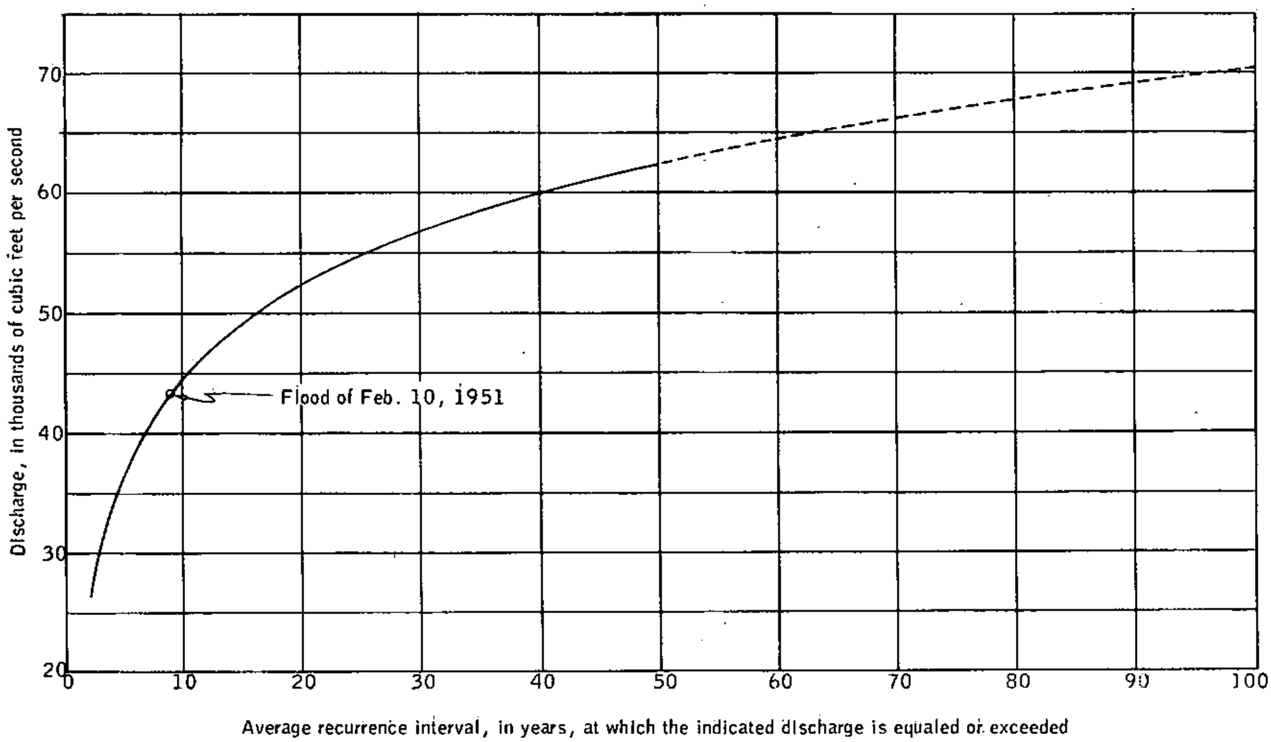
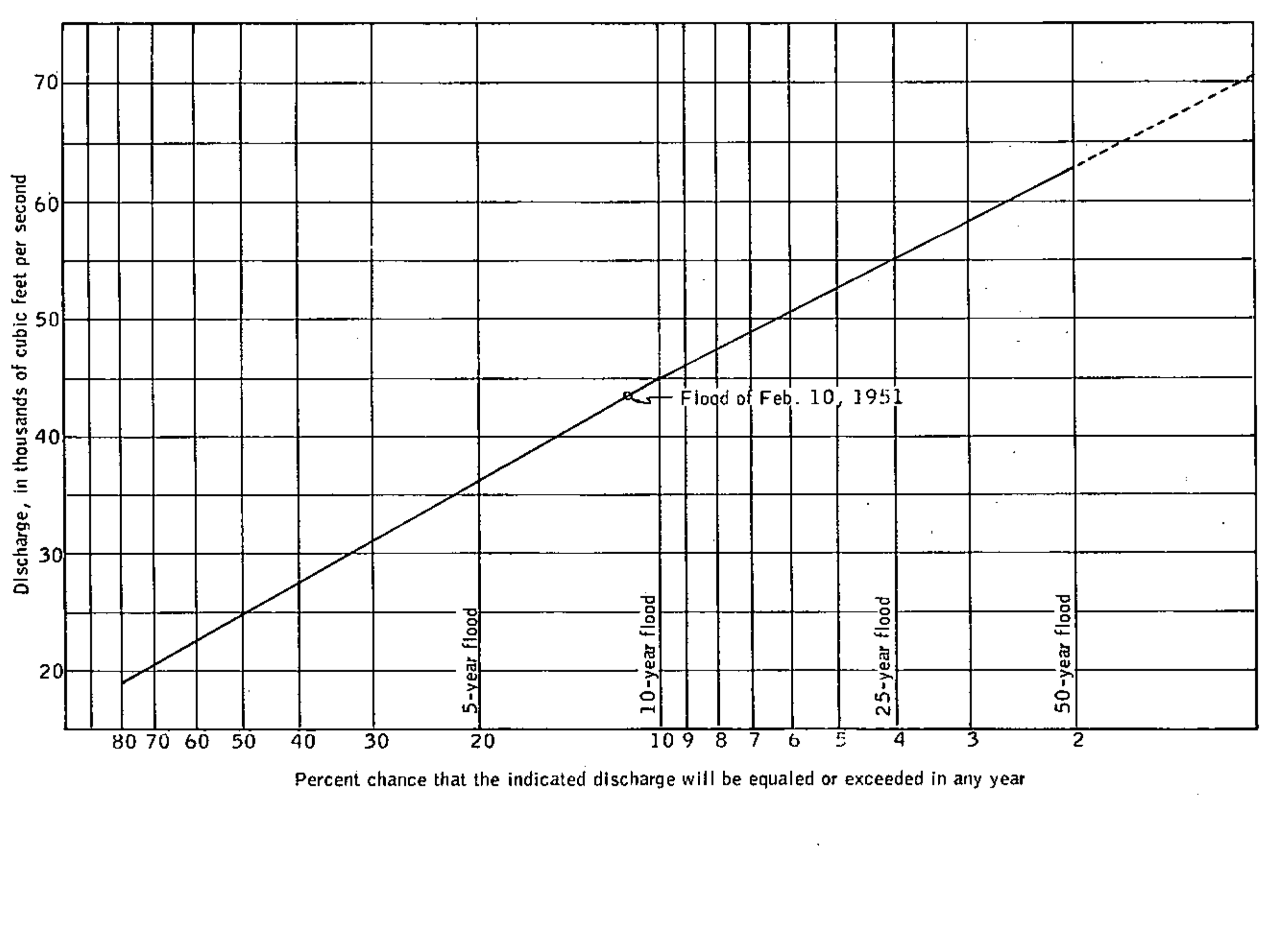


Figure 52. Magnitude and percent chance of annual floods, Nooksack River at Deming.



the same water year sometimes have but slightly less magnitude than the "annual flood."

In the Nooksack River basin the "annual floods" occur predominately during the period October to February. It may be of interest to note that during the last 24 years, and for the known 5 floods of earlier years for which there is valid information, an "annual flood" has occurred only 3 times outside the October-February period--one each during April, May, and June. The distribution of the 29 "annual floods" of record according to their occurrence by months is shown in the following table:

Table 30. Monthly "Annual Flood" Occurrences.

Month	Number of occurrences	Month	Number of occurrences
October	5	February	3
November	4	March	0
December	6	April	1
January	8	May	1
		June	1

MAGNITUDE AND FREQUENCY OF FLOODFLOWS

The method of analysis used herein to estimate the magnitude and frequency of floods is the same as that currently used by the U. S. Geological Survey 1/ in other areas. The conclusions drawn from the analysis are derived from streamflow data collected at various gaging stations in the general area during the 46-year base period 1912-57. The flood records used include those of the Nooksack River basin and those from adjacent river basins that the study showed to have similar basin characteristics. Although the graphs in this report have been extrapolated to provide estimates of magnitudes of floods up to a 100-year recurrence interval, they are based on observation only up to the 50-year recurrence interval.

The flood-frequency data are presented by two graphs. In figure 51 the graph sets forth the average recurrence interval at which a flood of a given magnitude may be equaled or exceeded. For example, the flood of February 10, 1951, at Deming, which had a peak discharge of 43,200 cubic feet per second, can be expected to be equaled or exceeded on an average of once in 9 years. In figure 52 the flood-frequency data presented in figure 51 have been converted to probability of occurrence; instead of showing the magnitude of a flood in relation to the average recurrence interval, it is shown in terms of chance of occurrence in any year. For example, the graph shows that the flood of February 1951 has a chance of about 11 to 12 percent of occurring in any one year.

Estimates of flood frequency are based on the assumption that events of the future will have the same average frequency as events that were experienced in the past. It is well to note, however, that although the probable average frequency of a flood of given size can be estimated, the time of its next occurrence cannot be predicted. For example, a flood of 50-year magnitude may be expected to occur twice in 100 years, but it is possible for two 50-year floods to occur in consecutive years. Therefore, flood-frequency data can be used in the design of flood-control projects, such as dikes, levees, and storage dams, and in the design of bridge and culvert openings, but cannot be used to forecast the time when a flood will occur.

1/ Dalrymple, Tate, 1960, Flood-frequency analyses, pt. 3 of Manual of hydrology: U. S. Geol. Survey Water-Supply Paper 1543-A, p. 1-80.

FLOOD AND DRAINAGE CONTROL IN THE NOOKSACK RIVER BASIN

(By G. M. Hastings, Division of Flood Control)

The widespread floods of December 1933 and January 1934 focused the general public's attention on flood control, and with the near disastrous conditions resulting again from the January 1935 floods, the 1935 Washington State Legislature replied to the demands and desires of the people by its enactment of several flood control laws. These laws related to the following: (1) flood control district organization, authorizing counties to levy a one-mill river improvement tax; (2) establishing flood control zones with the state assuming full regulatory control over all waters; (3) establishing a state policy for flood control and cooperation with all local and federal agencies; and (4) carrying out state participation with local municipal corporations in flood control maintenance subject to flood conditions. In the enactment of these laws the 1935 Legislature declared "it is the purpose of the state in the exercise of its sovereign and police powers, and in the interests of public welfare, to establish a state policy for the control of floods to the extent practicable and by economically feasible methods" and stated that "the prevention and alleviation of flood damages is a matter of public concern as affecting the health, safety, and general welfare of the state."

To carry out such a policy, the Division of Flood Control was created within the Department of Conservation. Pursuant to the 1935 Flood Control Zone Act, sixteen major rivers were designated flood control zones, the Nooksack River being Zone No. 8 (see pl. 7). Within these sixteen zones no improvement, public or private, shall be constructed, reconstructed, modified, nor shall any such improvement which was constructed, reconstructed or modified after March 22, 1935, be maintained or operated without a written permit from the supervisor of flood control. The supervisor may examine, approve, or reject all plans for new construction or for reconstruction or modification of existing improvements. Any improvement operated or maintained within a zone in violation of any order of the supervisor shall be presumed to be a public nuisance and may be abated. The supervisor assumes no jurisdiction over structural designs but is solely concerned with the probable effect of proposed works and structures on the safe passage of flood waters, their probable influence on the regimen of streams and bodies of water, and with any adverse effect such proposed works and structures may have upon the security of life, health, and property.

When state funds are available, any municipal corporations (towns, cities, and counties) and diking, drainage, irrigation, flood control, and soil conservation districts subject to flood conditions may receive financial assistance from the state in the cost of proposed flood control maintenance projects, normally on a 40 percent state fund basis. Such projects shall be for the purpose of maintaining and restoring normal, stable stream-channel alignment and capacity; for carrying off flood waters with a minimum of bank erosion damage or overflow on adjacent lands and property; and for restoring, maintaining, and repairing natural conditions, works, and structures for the maintenance of such conditions.

As stated previously in the section on flood history, origin, and magnitude, there are no records for flood discharges, stages, and damages prior to 1935 for the Nooksack River basin. Severe floods have been recorded as occurring in January 1935, October 1945, November 1949, and February 1951. Such floods inundate much of the cultivated lowlands of the Nooksack valley and portions of the towns of Everson, Ferndale, and Marietta. In addition, a portion of the flood waters overtop the low divide between the Nooksack and Sumas valleys near Everson and aggravate flood conditions in the Sumas basin, both in the United States and Canada. In their "Review of Reports on Flood Control of Nooksack River," April 25, 1952, the Corps of Engineers reported that the amount of land flooded and the depth to which it is flooded depend not only on the crest discharge, but also on the duration of the flood, local failures of levees, and formation of ice and drift jams. The 1935 flood is the only flood for which there is complete information available concerning the area inundated and the use of that area. That flood, although its crest discharge has been exceeded three times in the past seventeen years, is believed to have flooded a larger area than did the subsequent higher-crested floods. Of the 17,200 acres flooded in the valley in 1935, about 8,944 acres were in pasture and forage cropland, 3,612 acres were in grain cropland, 3,784 acres were in swamp and brushland, and the remaining 860 acres included fruit and specialty cropland and portions of Ferndale, Everson, and Marietta. Within the flood zone were tracks of the Northern Pacific Railway and the Chicago, Milwaukee, St. Paul and Pacific Railroad and several miles of state and county roads. Damage to buildings in 1935 is unknown, but during the 1951 flood, major damage occurred to 450 homes, 350 farm buildings, and 150 other types of buildings and affected 450 families. No lives have been lost as a direct result of floods in the Nooksack River basin. Plate 7 shows the boundaries of the Nooksack Flood Control Zone No. 8, established pursuant to Chapter 159, Laws of 1935, and the area that was theoretically inundated by the flood of February 1951, the maximum discharge of record. The entire shaded area was not actually inundated in 1951 but, on the basis of that flood stage and accompanying surface water gradient, similar recurring floods could inundate several portions or all of the area by a progressive combination of (1) bank and dike failures; (2) time of crest duration; and (3) ice and drift formation and their locations. During a particular flood of such magnitude all lands, property, and people are subject to damage and inundation within this theoretical flood area.

Floods in the Nooksack River basin result in damage to lands through bank and sheet erosion, through deposition of sand, gravel, and debris, and through spreading of weed seeds. Damage also occurs to crops, to farm and urban buildings and their contents, to roads, to railroads and utilities, and to dikes and bank protective works. The average annual damages, based on 1951 conditions and prices, were estimated by the Corps of Engineers to be $246,300 including $23,900 in the Sumas River basin. In addition to this tangible damage appraisal there are certain intangible flood damages which cannot be reduced to a monetary basis, such as endangering lives and pollution of wells and municipal water supplies. Fear of floods no doubt retards economic growth and causes some land to be utilized at less than its full economic potential.

No reasonable estimate can be made on the total cost of flood control work performed in the Nooksack River basin since its habitation. There are no records showing the value of flood control works constructed by individual landowners over the years. However, between 1935 and 1940 the Works Progress Administration constructed flood control improvements at more than 20 locations costing $378,000 and consisting of brush revetments, shear cable, snagging, and diking. During the period 1935 to 1960 the Corps of Engineers have expended $216,000 in snagging, repairing, and strengthening of dikes, stabilization of banks, and restoration of the Lummi Channel intake works. From March 1943 to September 1960 the state, through the Division of Flood Control, has participated in the cost of flood control maintenance projects in the Nooksack Basin. This maintenance involved pile and timber groins and shear walls (which have given way to rock riprap in recent years), channel rectification, dike repair, and debris removal on an estimated 150 projects. State funds expended amount to $488,954 with total project costs amounting to approximately $1,250,000. The other participating agencies are Drainage District No. 1 (Fishtrap Creek), Drainage District No. 2 (Schneider Ditch), Drainage Improvement District No. 15 (Saar Creek), Macauley Creek Flood Control District (Macauley and Smith Creeks), and Whatcom County Soil Conservation District, Whatcom County and Corps of Engineers (entire Nooksack River basin). The WPA, Corps of Engineers, and state expenditures do not represent the total cost of flood control works and improvements constructed in the basin, since from time to time when state funds were not available, local authorities proceeded with needed work with 100 percent local funds and no complete record of these local efforts is available. However, a conservative estimate of the total funds expended on flood control in the Nooksack basin since 1935 approaches $2,000,000.

On January 31, 1946, Congress requested the Corps of Engineers to review their 1942 report on flood control of the Nooksack River for the purpose of determining whether or not a federal flood control project would be economically feasible, the 1942 report being unfavorable. By their review report of April 25, 1952, in compliance therewith, the Corps of Engineers considered and carefully investigated all possible methods of reducing flood damages in the Nooksack River basin (channel improvement, diversion, diking, and storage) and determined costs and resulting benefits, based on a standard project flood of 125,000 cubic feet per second. This standard project flood was considered by the Corps of Engineers to be the maximum flood that could reasonably be expected to occur. The conclusions of their report are presented in table 31.

The benefit-cost ratios indicated that no federal projects could be justified under the then existing state-of-basin development. The review summarized further, however, that small levee and revetment projects would from time to time become justified and that continuing efforts of local interests could most efficiently provide for such projects.

It is fully appreciated and understood that a federal project must provide for complete protection, that is, standard project flood of 125,000 cubic feet per second (Corps of Engineers estimate). The maximum flood of record at Deming as reported by the Corps of Engineers had a discharge of 44,500 cubic feet per second (February 1951) and a recurrance interval of approximately nine years. By extrapolating their curve representing recorded maximum flood discharges it is shown that a flood of 65,000 cubic feet per second at Deming is likely to occur once every 100 years.

It is believed by state and Whatcom County officials

Table 31. Flood Control Cost-Benefit Ratio--Nooksack River.

Project	Annual Costs	Annual benefits	Benefit-cost ratio
Channel improvements:			
Dredging at mouth (annual maintenance) ---	$ 65,000	$ 49,000	0.8
Diversion:			
To Lake Whatcom ---	685,000	250,000	0.4
To Samish River ---	245,000	125,000	0.5
To Lummi River ---	26,900	16,500	0.6
Levees:			
Right bank below Ferndale ---	23,600	11,500	0.5
Left bank at Marietta ---	1,700	1,100	0.6
Left bank, Ferndale to Marietta ---	26,400	10,000	0.4
Right bank, Lynden to Everson ---		over $240 per acre	
Left bank, Everson to Ferndale ---		over $300 per acre	
Right bank, Everson to Lawrence ---	27,400	15,000	0.5
Storage:			
Edfro Creek site			
74,000 acre-feet ---	568,000	245,000	0.4
36,000 acre-feet ---	451,000	123,000	0.3
Wells Creek site			
46,000 acre-feet ---	550,000	165,000	0.3
Deming site			
120,000 acre-feet ---	837,000	262,000	0.3
35,000 acre-feet ---	507,000	125,000	0.2

and Nooksack River basin residents that the standard project flood sights should be lowered to a more realistic level, possibly that of a fifty year flood. In light of the present economic level of development in the basin and corresponding damages likely to accrue ($246,300 annually), a lower standard project flood would decrease project costs accordingly and cause benefit-cost ratios to improve and become economically feasible. By this thesis it is acknowledged that complete protection might not be achieved, but at the price of the present extreme vulnerability of the basin, accomplishment of a lesser, calculated degree of protection may be justified and at a risk the local interest can well afford and are willing to assume. Preparation for such reappraisal and determination of benefit and costs are being made by the state and a review of the 1952 Corps' reports has been authorized. It is hoped that the results of these combined cooperative reviews and studies may be available within the next two to three years.

WATER DEVELOPMENT SITES

INTRODUCTION

Three basic types of water development projects are suitable to the report area. These include the major reservoir storage sites and power diversion sites of the upper basin, and the minor storage sites of the lower basin. The approximate site locations and maximum inundation areas are shown on plate 8.

Considerable geologic work has been done on the four major areas of development although additional study would be required to determine in more detail the feasibility of these sites to the uses proposed. The smaller storage sites have been examined in only a precursory manner, while diversion sites are based largely on estimations following field studies.

Earthquakes must be considered in the design of any storage or diversion project as western Washington is an area of considerable seismic activity. Most of the earthquake shocks have been of low to moderate intensity, but a few have been severe. A large majority of them have originated in or near Puget Sound. Between the years 1856 and 1934, twenty-one earthquakes were recorded for northwest Washington that were probably felt in the Nooksack River basin, six of these having their epicenters within the basin. From review of past earthquake activity in the basin, it is evident that a dam and its appurtenant structures will be subject to numerous earthquakes mostly of low intensity but occasionally reaching an intensity of VI to VII on the modified Mercalli scale, causing moderate damage. In general, earthquakes will be more severe in the lower parts of the basin than in the upper parts. On the seismic map of the United States, the U. S. Coast and Geodetic Survey has placed the lower basin and the downstream portions of the upper basin in zone 3, subject to major damage. The Maple Falls, Edfro Creek, and all sites farther west are included in this zone. The remainder of the basin is placed in zone 2, subject to minor damage.

MAJOR DAM AND RESERVOIR SITES

This discussion is based on several government reports which are listed in the bibliography. These reports discuss four major water utilization areas in the basin which include the Nooksack River Utilization Area at Deming, the North Fork River Utilization Area, the Maple Falls River Utilization Area, and the South Fork River Utilization Area. The North Fork area includes as alternates the Shuksan and North Fork dam sites while the South Fork area includes as alternates the Skookum and Edfro Creek dam sites. The four major areas are all accessible by hard surfaced all-weather highways with the exception of the South Fork area and the Wells Creek portion of the North Fork area which are reached by gravelled logging roads.

Table 32 shows the estimated power available at the major reservoir and diversion sites. With the exception of Maple Falls, all the major sites are considered multipurpose and, therefore, power development may be sacrificed in order to utilize more water for irrigation, municipal supply, and other uses. Varying amounts of power are available at each site depending upon the following factors: location of powerhouse, which dam is selected where alternates are available, and, in the case of the Deming site, what large diversions occur upstream. It is estimated that a maximum of 70,800 kilowatts could be developed at these sites. However, when other uses are considered the estimated 70,800 kilowatts for 99.9 percent of the time may well be much greater than any feasible development from the major sites. On the other hand, Nooksack basin plants could be coordinated on an interbasin basis under a program of hydraulic and electrical integration and thus sharply increase the amount of firm power output. Likewise, the expanding electrical integration program may eliminate the need for storage dams for power purposes on the Nooksack River and develop more firm power with river run plants.

NOOKSACK RIVER UTILIZATION AREA AT DEMING

This is perhaps the most controversial of the major dam sites in the basin as this site would flood the villages of Acme, Clipper, Comar, Standard, and Van Zandt, together with 3,000 acres of rich farm land and an additional four to five thousand acres of land that could be brought under cultivation. Extensive railroad and highway relocation would also be required. The site is located on the main Nooksack River three-quarters of a mile upstream from Deming at about river mile 36.8 on the Corps of Engineer's river survey map. It would tap the greatest drainage area of any site in the basin, 582 square miles, and also provide the largest amount of storage, as much as 500,000 acre-feet.

Above Deming the watershed is made up of many precipitous high mountains interlaced by a network of narrow canyons. This region encompasses 77 percent of the total area drained by the Nooksack River system and produces more than 90 percent of the basin's total runoff.

Based on streamflow records at Deming, an average of 2,400,000 acre-feet of water passes the site annually. Owing to dissimilar runoff patterns, peak flows do not occur on the three forks of the Nooksack River simultaneously. However, major flooding occurs on the main stream of the river usually during heavy precipitation periods in the late fall or in the spring when runoff from snowmelt is accompanied by moderate precipitation. To provide adequate storage capacity for flood control purposes it would be necessary to maintain a reduced reservoir level during periods of potential flooding. The required reservoir level regulation would to some extent decrease the maximum possible power generation at the Deming site.

At the Deming site, the valley is constricted by a ridge of rock and glacial debris extending southward from the right valley wall. Two pre-glacial river channels now filled with drift cut this ridge. The exact dam location has not been selected since further geologic determinations will be required. Existing studies indicate the minimum dam section location to be in the E½ of Sec. 6, Twp. 38 N., Rge. 5 E., between the bedrock left wall and the small bedrock ridge on the right bank. However, before this axis can be considered, certain problems of leakage through glacial deposits, bedrock of the ridge, and the two pre-glacial stream channels must be resolved. Test pits, exploratory drilling, and laboratory permeability tests must be conducted to assess these problems.

An alternate axis is located about 2,800 feet downstream where bedrock is encountered about 140 feet below the stream bed. The right abutment of this site is superior to that of the former in that it abuts against the broad upper portion of the ridge extending southward from the right valley wall. Thus the danger of instability and leakage through the long narrow portion of the ridge is eliminated and the buried pre-glacial channel is not a problem. The chief disadvantage of this site is the greater cross sectional area of the valley and correspondingly larger dam required.

The maximum reservoir level at the Deming site is limited to an elevation of 320 feet because the divide between the South Fork valley and the Samish River is only 322 feet above sea level. This would permit a dam 113 feet high storing slightly under 500,000 acre-feet and inundating 9,800 acres of land. Storage could be increased with construction of a dam on the ridge between the South Fork and Samish River valleys. However, this would probably not be required since a storage capacity of 500,000 acre-feet of water would insure almost complete flood protection for the lower basin. Figure 53 shows the various capacities for dams of different sizes at this site based on Helland's report. The U. S. Army Corps of Engineers' standard project flood is 125,000 cubic feet per second and would require total storage of 420,000 acre-feet. There is no record of a flood of this magnitude having occurred in the Nooksack River basin and the probability of such a flood ever occurring is unlikely.

Flood control storage and subsequent water use

Table 32. Estimated Power Available, Nooksack River Basin.

Site	Stream	Drainage Basin sq miles*	Mean Effective Head	Natural Flow Available (cfs) 50% time	90% time	99.9% time
				POWER DEVELOPMENT AT		
Deming	Nooksack River	582	100 feet	*3,000	1,400	660
Deming (with Edfro Diversion to Skagit River)	Nooksack River	582	100 feet	*2,460	1,270	590
Shuksan - powerhouse upstream	North Fork Nooksack River & Wells Creek	85	220 feet	* 520	300	90
powerhouse downstream	North Fork Nooksack River & Wells Creek	85	605 feet	* 520	300	90
North Fork	North Fork Nooksack River & Wells Creek	88	*600 feet	* 520	300	90
Maple Falls - powerhouse below dam	North Fork Nooksack River	226	100 feet	900	400	150
powerhouse downstream	North Fork Nooksack River	226	200 feet	900	400	150
Edfro Creek - Lyman Powerhouse	South Fork Nooksack River	100	550 feet	* 530	135	60
South Fork Powerhouse	South Fork Nooksack River	100	340 feet	* 530	135	60
Skookum Creek - Lyman Powerhouse	South Fork Nooksack River	103	*550 feet	* 540	140	60
South Fork Powerhouse	South Fork Nooksack River	103	*340 feet	* 540	140	60
				POWER DEVELOPMENT AT		
Swamp Creek	Swamp & Ruth Creeks	14	*833 feet	90	90	10
Glacier	North Fork, Nooksack River, Deer Horn, Lookout, Coal, & Canyon Creeks		920 feet	700	300	110
Warnick	North Fork Nooksack River	190	160 feet	800	370	140
Glacier Creek	Glacier, Falls, Coal, Deep, Davis, Little, Gallop, Cornell, & West Cornell Creeks		1,300 feet	180	75	25
Clearwater Creek	Middle Fork Nooksack River, Wallace, Warm, & Clearwater Creeks	44	720 feet	200	110	60
Wanlick Creek	South Fork Nooksack River, Howard Creek	37	900 feet	200	40	25

* Figures determined by Division of Water Resources

Kilowatts Available Without Regulation			Regulated Flow Available (cfs)		Kilowatts Available Regulated Flow	
50% time	90% time	99.9% time	50% time	99.9% time	50% time	99.9% time
MAJOR RESERVOIR SITES						
20,300	9,400	4,400		2,600		17,600
16,600	8,600	4,000		1,950		13,200
7,700	4,400	1,300	650	600	9,600	8,900
21,300	12,300	3,700	650	600	26,600	24,500
21,100	12,200	3,600	650	600	26,400	24,400
6,000	2,700	1,000	950	660	6,400	4,400
12,100	5,400	2,000	950	660	12,800	8,900
19,700	5,000	2,200		650		24,200
12,200	3,100	1,400		650		15,000
20,100	5,200	2,200		650		24,200
12,400	3,200	1,400		650		15,000
DIVERSION SITES						
5,100	2,200	500	No Regulation			
43,600	18,700	6,800	700	615	43,600	38,300
8,600	4,000	1,500	850	650	9,200	7,000
15,800	6,600	2,200	No Regulation			
9,700	5,300	2,900	No Regulation			
12,200	2,400	1,500	No Regulation			

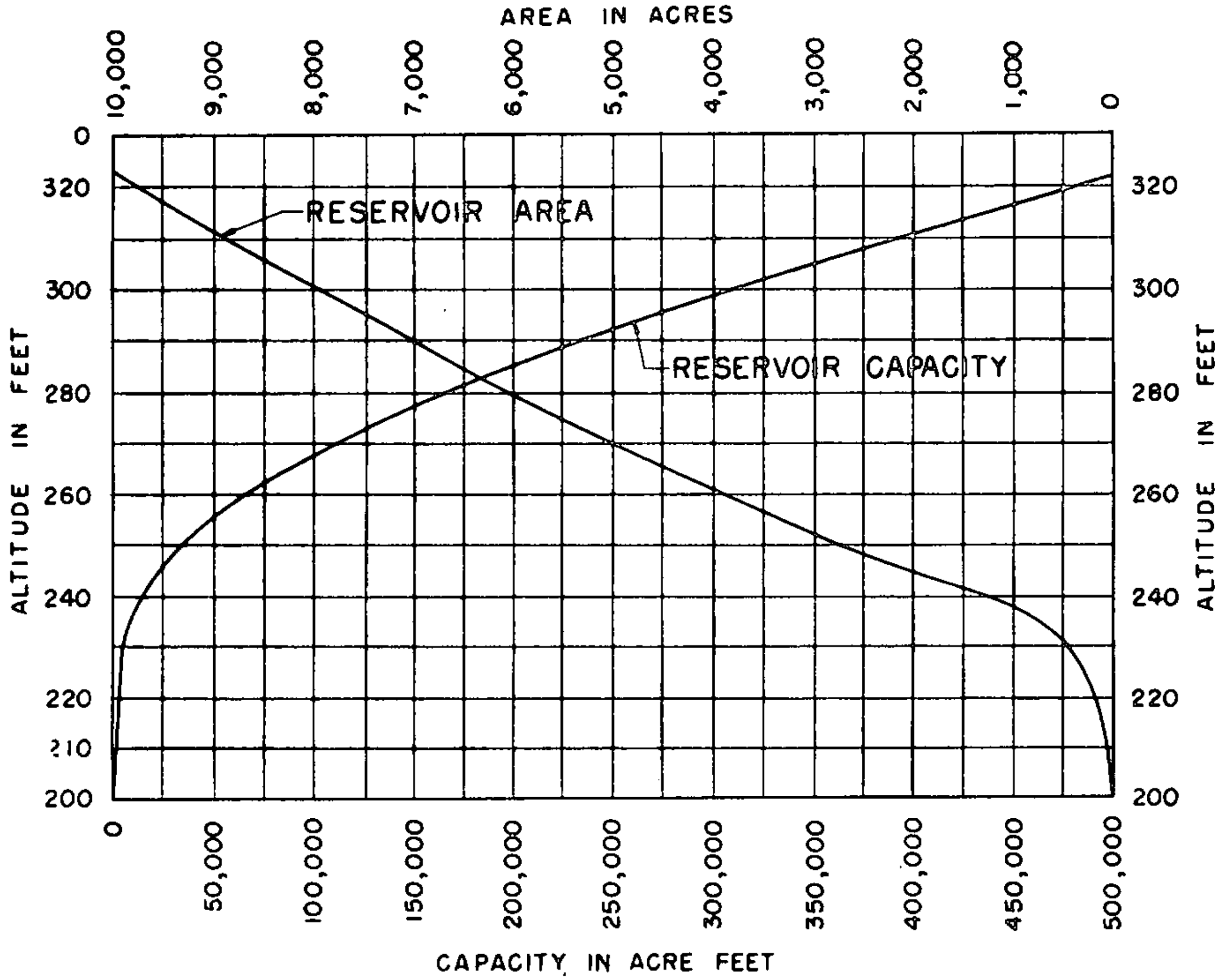


Figure 53. RESERVOIR AREA AND CAPACITY CURVES, DEMING DAM SITE.

are the primary justifications for a dam at the Deming site. Some power could be generated at the site although use of the reservoir for flood control purposes would reduce power generation.

Helland assumed use of this reservoir primarily for power purposes, with a large dam providing 450,000 acre-feet of useable storage. After allowing for evaporation losses, an average controlled flow of 2,600 cubic feet per second would be available 99.9 percent of the time, providing a power potential of 17,600 kilowatts. However, development of power on the South Fork at the Edfro or Skookum Creek sites with diversion to the Skagit basin for power purposes would reduce the available flow at Deming to 1,950 cubic feet per second for 99.9 percent of the time, thereby reducing the power potential to 13,200 kilowatts.

Irrigation, public supply, or other consumptive demands must be evident before further consideration could be given to construction of a dam at the Deming site.

Smaller structures primarily for flood control purposes have also been considered at this location by the Corps of Engineers and cost, storage, and benefit estimates have been made for reservoirs with 252 foot and 274 foot pool levels. These figures are presented in table 31 of the Flood Control Section of this report. Any dam constructed here would require fish passage facilities to insure continuation of the Nooksack River as a spawning area for anadromous fish.

NORTH FORK RIVER UTILIZATION AREA

There are three possible storage sites in the area of Nooksack Falls, but the two on the North Fork of the Nooksack are alternates and only one could be built. Power would be a primary purpose here with flood control also being important. Ideal development would divert water from the Wells Creek project to whichever reservoir is constructed on the North Fork. Development of the North Fork or Shuksan sites, together with Wells Creek site is essential for effective power development farther downstream on the North Fork.

Shuksan Dam Site.

This dam site is located in Sec. 34, Twp. 40 N., Rge. 8 E.W.M., (unsurveyed) at river elevation 1,890 in a reach of the North Fork valley that is partly filled with intravalley bedrock hills. Bedrock is exposed in the bed of the North Fork at the dam site, and no buried channels bypass

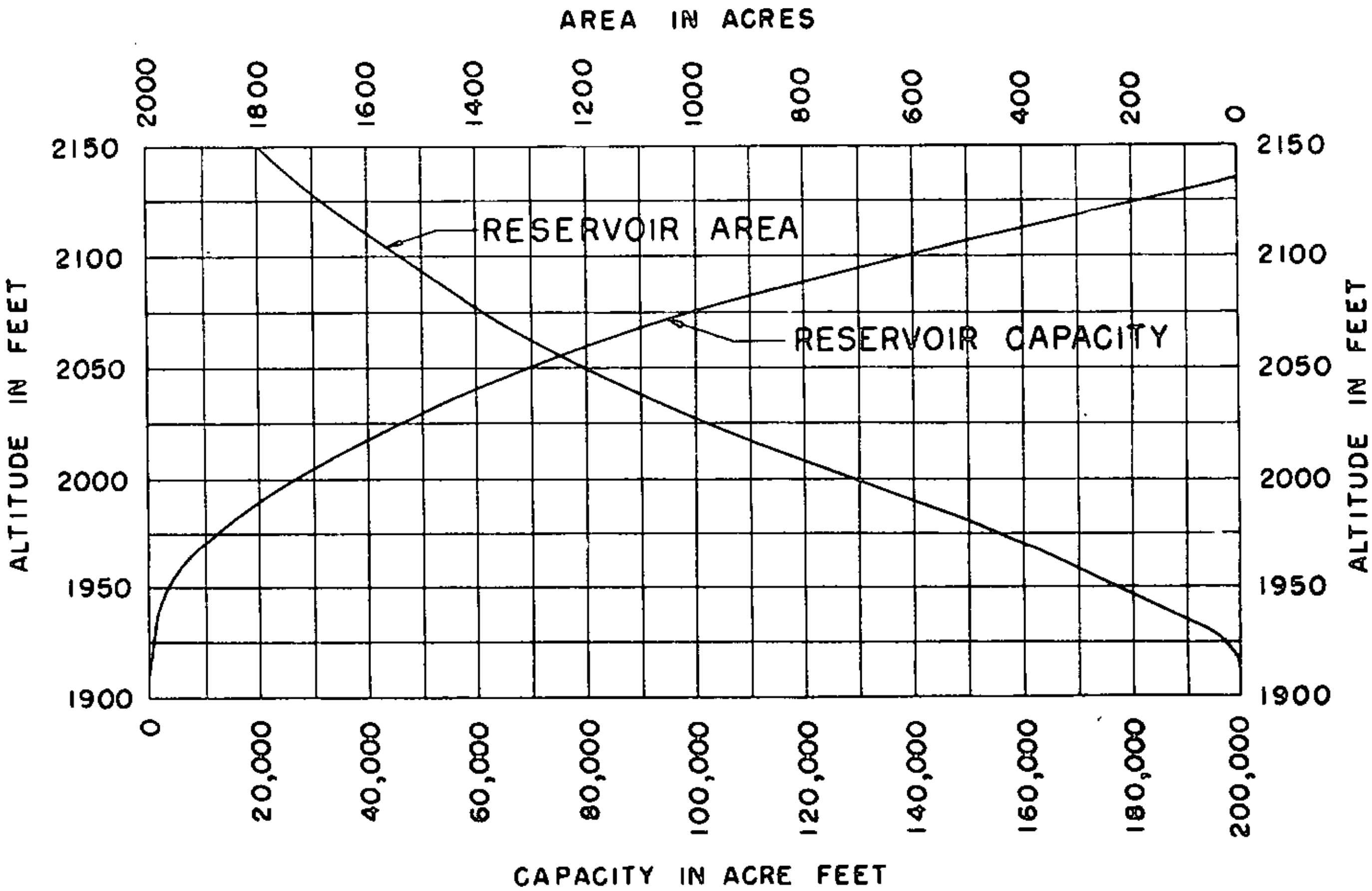


Figure 54. RESERVOIR AREA AND CAPACITY CURVES, SHUKSAN DAM SITE.

the site. The foundation and both abutments are underlain by greenstone which is adequate to support any type of dam of the required height. A possible spillway site is located in a small valley on the left abutment, and a possible site for an outlet works tunnel is located 300 feet south of the river.

Recommendations for further geologic study include exploration of the foundation and both abutments by drilling and field permeability tests, exploration of the area of crushed rock downstream from the dam site by drilling to obtain data to evaluate its effect on the dam site, exploration of the contact zone behind the left abutment by drilling and field permeability tests, and examination of gravel deposits that may be used for concrete aggregate to determine possible deleterious effects of greenstone pebbles on concrete.

Excluding any additional contributions from Wells Creek, the North Fork above this point drains approximately 64 square miles and produces an annual runoff of about 340,000 acre-feet. Streamflow patterns in this area are very erratic but, similar to that at Deming, rather consistent high flow periods occur in fall and spring. The high altitude and lower temperatures cause the lowest flows to occur mostly in winter. Another less pronounced low flow period occurs after most of the snowpack has melted in late summer, but here again glacial melt plays a prominent part in maintaining flow.

A reservoir level at 2,052 feet would provide annual equalization of the flow in the North Fork, while a level of 2,073 feet would equalize both Wells Creek and the North Fork. However, a reservoir level of 2, 130 feet with a dam height of 215 to 245 feet would be desirable for both power and storage purposes. Such a structure would store 200,000 acre-feet of which 110,000 acre-feet would accomplish flow equalization for power purposes while the additional 90,000 acre-feet would be available for flood-control purposes. Assuming a 5-day flood, 90,000 acre-feet would provide considerable flood relief by containing 9,000 cubic feet per second for the flood period. Figure 54 shows the various capacities for different height dams at the Shuksan site based on Helland's study.

There are two potential powerhouse locations here. An upstream site is available just below the dam at altitude 1,858 and would have a mean head of 220 feet. Allowing for evaporation, an estimated minimum controlled flow of 600 cubic feet per second would be available for a potential capacity of 8,900 kilowatts for 99.9 percent of the time. An alternative powerhouse site is below Nooksack Falls, about 3 miles downstream from the dam. This plan would provide about 605 feet of available head and be capable of generating 24,500 kilowatts for 99.9 percent of the time and, with a minimum flow of 650 cubic feet per second for 50 percent of the time, could generate 26,600 kilowatts.

North Fork Dam Site.

This site is an alternate dam location to the Shuksan site and is located 1½ miles downstream from the Shuksan

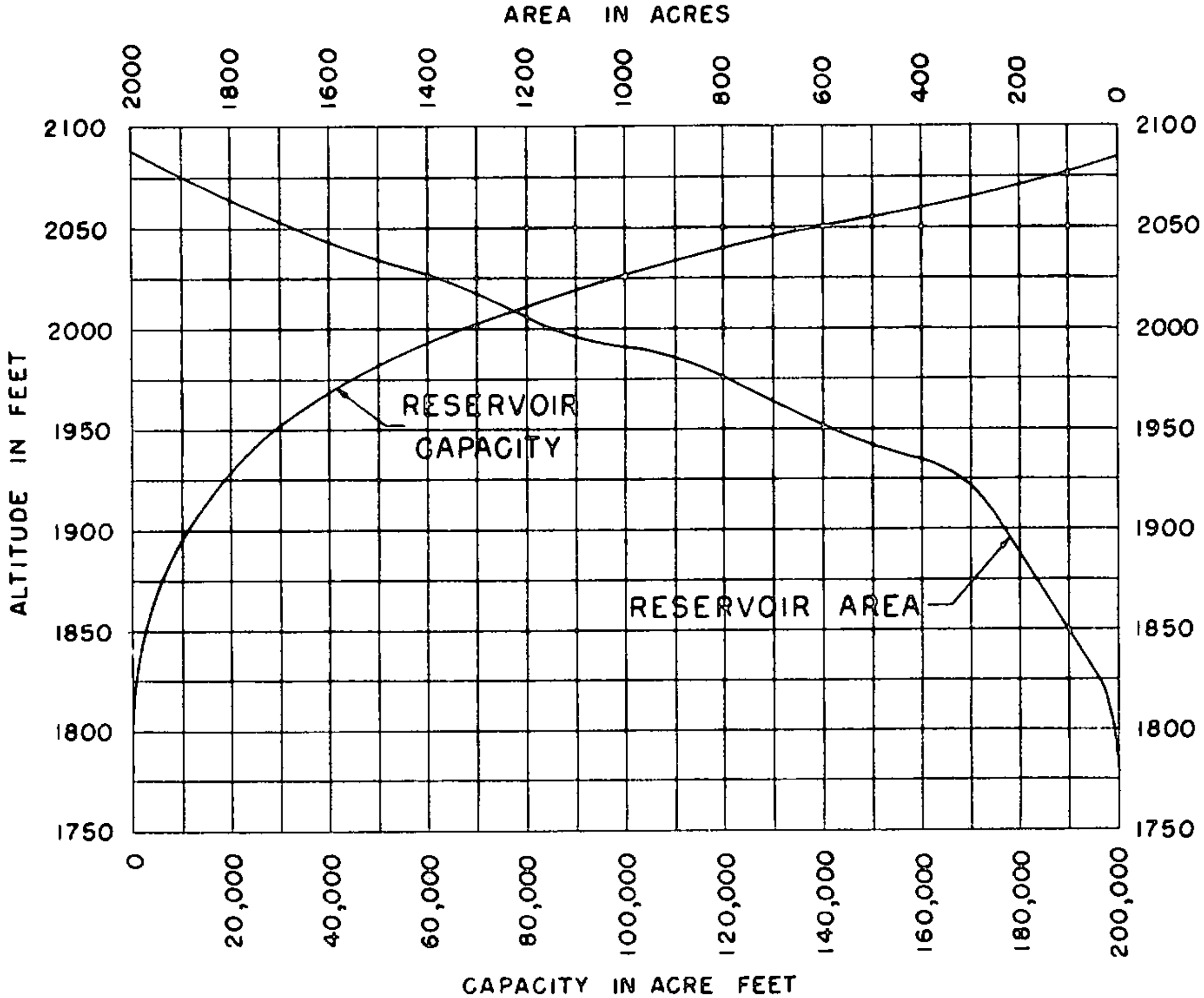


Figure 55. RESERVOIR AREA AND CAPACITY CURVES, NORTH FORK DAM SITE.

location. Drainage basin and flow characteristics here are similar to that at Shuksan, and complete development would also be dependent upon diversion of Wells Creek into the reservoir. Two potential dam axes were studied here. These are about three-quarters of a mile upstream from Nooksack Falls and 900 feet apart, being 66.3 and 66.7 miles above the mouth of the Nooksack River. Both sites are in Sec. 32, Twp. 40 N., Rge. 8 E.W.M. The lower of these two sites offers better foundation conditions although the presence of a permeable lava-argillite contact at altitude 2,000 feet means that any dam higher than 260 feet would be subject to possible leakage problems. A dam of this height could store but 67,500 acre-feet and from the standpoint of storage would be inferior to that at the Shuksan dam site. However, further geologic exploration may reveal that the problem of this permeable zone is not as serious as it appears and that a higher structure may be feasible.

The fundamental defect of the upper site is the strong probability of a buried valley beneath the lava flows in the left bank and the further possibility that the lower lava flow rests upon thick deposits of highly permeable fluviatile or glacio-fluviatile materials. The extent of this contingency can be determined only by further geological investigations. A pool elevation of 2,080 feet would be highly desirable and provide 193,800 acre-feet of storage and, together with the Wells Creek flow, would provide a minimum flow of about 600 cubic feet per second and a 50 percent flow of 650 cubic feet per second. A gross head of about 550 feet would be available by constructing only one mile of conduits and locating the powerhouse below Nooksack Falls.

A high dam at the North Fork site would provide flood control storage virtually identical with the Shuksan site, while available power would be slightly less. The area-capacity curves in figure 55, based on Helland's report, show the various capacities for different dams at the North Fork site.

Wells Creek Dam Site.

This is primarily a power project and, as pointed out in the preceding discussion of the Shuksan and North Fork dam sites, the Wells Creek site could best be developed in conjunction with either of the former. The dam site is located about 2.2 miles above the confluence of Wells Creek and the North Fork.

Above the dam site, Wells Creek drains about 21 square miles of Mt. Baker's north slopes, the estimated runoff from this area in an average year being about 115,000 acre-feet. No streamflow figures have ever been collected on this stream, but a similarity of terrain and topography indicates it would have streamflow characteristics similar to the Nooksack River at the North Fork and Shuksan sites.

Geologic conditions at this site appear favorable for dam construction. However, before construction is contemplated, preliminary studies should include determination of the boundaries of the greenstone mass in which the site is situated, chemical studies of the natural solubility of the rock, and various physical tests on the fresh and treated rock.

If the water impounded in the Wells Creek reservoir is diverted into either the Shuksan or North Fork reservoirs, as has been proposed, a conduit or tunnel will be required. A tunnel to either reservoir would follow the same route, and it is probable that the tunnel would pass through greenstone and argillite and would be approximately 8,000 feet in length. If an open conduit were used it would be about 22,000 feet in length to the Shuksan reservoir and about 13,750 feet in length to the North Fork reservoir and would traverse rugged terrain in places.

This site has a unique hazard potential in the possibility that Mt. Baker should again become active. Although all the sites on the North and South Forks of the Nooksack River are within range of heavy ash fall, the Wells Creek site is also within possible range of lava flows. A violent or prolonged period of volcanic activity would be expected to produce mud-flows and floods effects of which might be harmful in the river valleys far distant from the mountain.

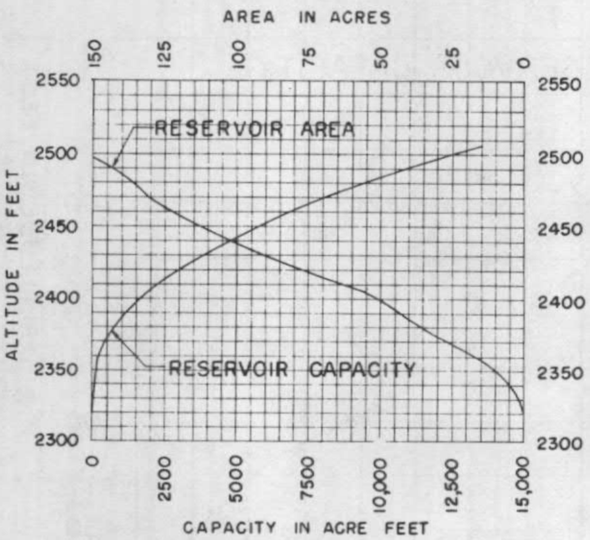


Figure 56. RESERVOIR AREA AND CAPACITY CURVES, WELLS CREEK DAM SITE.

Wells Creek also carries an exceptionally high sediment load and rather than construct a storage dam serious consideration should be given to the construction of a diversion dam only. Storage in the Shuksan or North Fork reservoirs would not be impaired if the structure were constructed so as to by-pass the flow if the sediment content becomes excessive. This would allow almost complete utilization of the flow of Wells Creek through the storage facilities in the larger reservoirs. An area-capacity curve for the Wells Creek site (fig. 56), based on Helland's studies, shows the small amount of storage available here, hence very little storage would be lost by constructing only a diversion dam. The power available at this site is included in the discussion of the North Fork and Shuksan development.

MAPLE FALLS RIVER UTILIZATION AREA

This proposed dam site is in a narrow, rock-walled gorge within Sec. 31, Twp. 40 N., Rge. 6 E.W.M., on the North Fork of the Nooksack River immediately below the confluence with Maple Creek. Power development would be the sole purpose for a dam at this site as reservoir storage would be negligible. Thus, stream regulation would have to depend on upstream structures such as the Shuksan or North Fork projects.

At this site the North Fork cuts a gorge in a course that has been superimposed upon the south bank of the pre-glacial valley. The pre-glacial valley is wider and deeper than the present valley and is partly filled with unconsolidated glacial deposits and alluvium. Rock in the foundation and both abutments consists of coarse, clastic conglomerates with interbedded sandstones and siltstones. Bearing capacity of this rock would be sufficient to withstand the loads imposed by either a masonry or an earthfill dam.

Chief defects of this site are: first, the possibility of excessive seepage loss from the reservoir through the unconsolidated sediments filling the pre-glacial channel, and second, the permeability of the rock making up the foundation and abutments of the dam site. Again, further exploration and test drilling is necessary to determine the rock profile in the right abutment and permeability of rock in the foundation with respect to controlling of seepage by grouting.

The highest apparent reservoir level at this site would be 590 feet requiring a dam of 95 feet above the stream bed and 105 to 110 feet above the rock foundation. This would provide about 6,000 acre-feet of useable storage.

With a regulated low flow of 660 cubic feet per second for 99.9 percent of the time and 950 cubic feet per second for 50 percent of the time, there would be 4,000 kilowatts available 99.9 percent of the time and 5,800 kilowatts 50 percent of the time if the powerhouse is located directly below the structure. Planning should also include studies of an alternative powerhouse location directly above the backwater from the proposed Deming dam at elevation 320 feet in Sec. 22, Twp. 39 N., Rge. 5 E.W.M., which would require a conduit of five miles in length. This location of the powerhouse would increase the effective head to 200 feet, and the available power would be increased by 120 percent.

SOUTH FORK RIVER UTILIZATION AREA

Skookum Creek and Edfro Creek are two alternate dam sites in the South Fork River Utilization Area. Power and flood control would be the primary purposes for either of these dams although future municipal, industrial, and irrigation requirements also offer reason for development. Construction of a dam in this area presently appears more favorable than in any of the preceding areas discussed.

Skookum Creek Dam Site.

This site is located on the South Fork of the Nooksack River just above the confluence of Skookum Creek.

The 103 square mile watershed above this site is considerably lower in elevation than that of the Shuksan or North Fork projects, but it lies in an area more favorably situated for precipitation and thereby receives comparable amounts of runoff per unit area. Excellent streamflow records are available immediately upstream from this location and indicate that this drainage area produces an average annual runoff volume of 535,000 acre-feet.

Owing to the absence of glaciers, however, streamflow characteristics are somewhat different than those of the North Fork. Here there is a definite tendency for the lowest flows to occur during the late summer after the snow pack has completely ablated, while the highest flows appear to be in fall and early winter followed by a lower peak period during the spring snowmelt season.

No geologic or engineering information is available on this site. However, field examinations indicate that a slightly larger dam structure would impound somewhat more water than the Edfro Creek dam site. Reservoir height, power and storage figures for Edfro Creek are, therefore, typical for this site. Some authorities feel that the Skookum Creek site may be superior to the Edfro Creek site; the Division of Water Resources, therefore, advocates a thorough study of both sites before a final selection is made.

Edfro Creek Dam Site.

This damsite is located on the South Fork of the Nooksack River, 2,000 feet above Edfro Creek. The drainage and flow characteristics are virtually identical with those at the Skookum Creek site with the only difference being that the flow of Edfro Creek itself would by-pass this site. Figure 57 gives the various capacities for the different size dams at this site as determined by Helland.

Suitable foundation conditions are probably too deep, being about 165 feet below river level, to consider excavation to bedrock for the foundation of a rigid dam. Although the valley fill has a complex arrangement, it might be possible to site

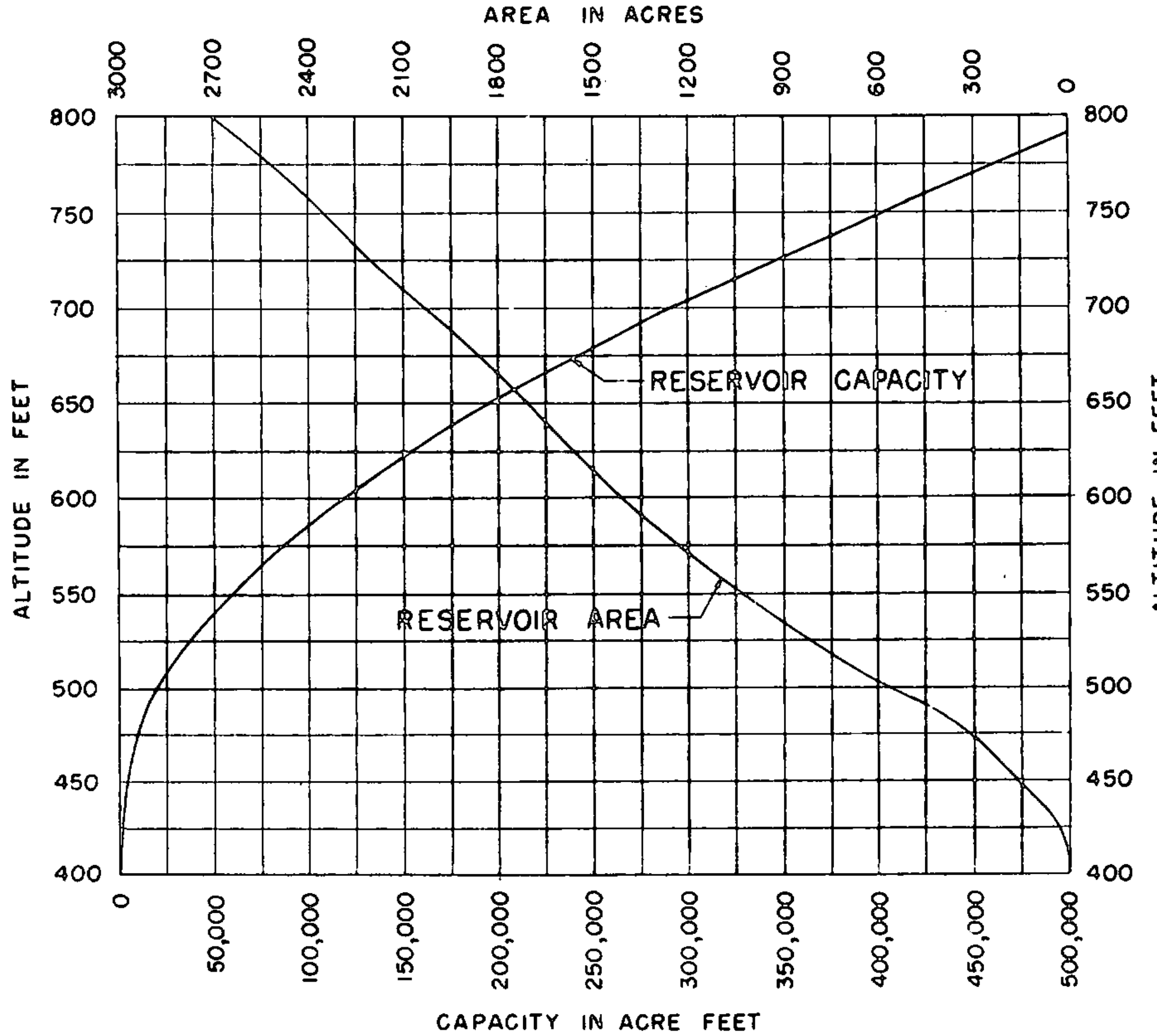


Figure 57. RESERVOIR AREA AND CAPACITY CURVES, EDFRO CREEK DAM SITE.

a flexible dam upon a silty middle layer which is about 35 feet below the river and about 100 feet in thickness. The lower layer of the fill should be disturbed as little as possible, and boreholes should be properly plugged before abandonment. A dam at this site could stand about 400 feet above river level and possibly 450 feet above the foundation. Since valley width increases rapidly above altitude 800 feet at the dam site, this elevation may mark the economic limit of a high dam for both power and flood control.

The record of discharge for this site shows that a storage capacity of 300,000 acre-feet would enable equalization of flow permitting a constant release of 650 cubic feet per second after allowance for evaporation loss, and this much storage would enable a somewhat greater release in most years. Helland proposes to develop the power of the South Fork by diversion to the Skagit River near Lyman. Assuming diversion at an altitude of 620 feet, a dam 220 feet high would be required to raise the water to the tunnel intake. Thus, a 370 foot high dam with spillway at 770 feet elevation, would be required to provide 300,000 acre-feet of live storage. Total capacity of the reservoir would be 450,000 acre-feet. An additional 30 feet of height could be used for flood storage providing over 100,000 acre-feet for this purpose. The Corps of Engineers also discuss reservoir elevations at 562 and 521 feet and estimate flood prevention by such storage.

The Lyman power development would require a tunnel originating in Sec. 20, Twp. 36 N., Rge. 6 E.W.M., and terminating in Sec. 32. From there the water would be conveyed by a penstock to the powerhouse at elevation 60 feet at or near Lyman. After allowing for head losses, an estimated mean effective head of about 550 feet would be available at the turbine, with a corresponding power output of about 24,000 kilowatts 99.9 percent of the time.

An alternate plan would be to install the powerhouse directly below the dam. However, net power output would be 40 percent less due to only about 340 feet of head being available. With construction of the Deming dam, however, this loss would be offset by an additional 4,400 kilowatts produced at downstream plants.

MINOR DAM AND RESERVOIR SITES

There are thirteen smaller dam sites in the basin which are tabulated in table 33. These sites are all much smaller than those discussed in the preceding section, but are larger than normal farm pond size. The information and site locations on plate 8, "Water Development Projects," is included to show where possible storage may be available and further studies warranted.

All the information concerning these sites is based on

Table 33. Potential Minor Storage Projects, Nooksack River Basin.

Reservoir Name	Stream	Approximate Dam Location Sec. Twp. Rge.	Estimated Storage Acre-feet	Inundated Area Acres	Estimated Available Runoff Acre-feet	Remarks
Anderson Creek	Anderson Creek	W½8-38N-4E	3,800	85	15,000	
Barrett Lake	Tenmile Creek	SW¼21-39N-2E	1,100	110	33,400	
California Creek	California Creek	E½18-40N-1E	1,400	120	18,000	Conversion of tidal area to fresh water lake.
Dakota Creek	Dakota Creek	E½7-40N-1E	4,500	210	34,400	Conversion of tidal area to fresh water lake.
Deer Creek	Deer Creek	N½30 or 29-39N-3E	2,500	210	3,000	
Green Lake	Fourmile Creek	NE¼9-39N-3E	130	45	8,600	Regulation & development of existing lake.
Kelly Road	Unnamed tributary of Anderson Creek	NE¼5-38N-4E	700	480	1,500	
Lake Terrell	Terrell Creek	N½16-39N-1E	3,000	600	2,400	Raising & regulation of existing lake for water use downstream.
Maple Creek	Maple Creek	19&30-40N-6E	18,000	750	30,000	No known use at present.
Markworth Road	Unnamed Stream	NW¼10-40N-2E	700	30	800	
Tenmile Creek	Tenmile Creek	22 or 26-39N-3E	8,750	580	7,400	Suitable for partial or complete development dependent upon demand.
Saar Creek	Saar Creek	12&13-40N-5E	11,000	230	15,000	
Upper Bertrand	Unnamed tributary of Bertrand Creek	NE¼3-40N-2E	1,600	100	1,000	

estimates following precursory field examinations to determine whether a site actually existed. No geological reconnaissance has been done to ascertain the geological feasibility of any of the sites. However, runoff estimations are based on the same assumptions predicating the streamflow analysis section of this report and, thus, are quite accurate. In all cases, sufficient water is available to merit inclusion of these sites as possible storage reservoirs. However, reservoir capacities are calculated from available U.S. Geological Survey topographic maps, and because of the absence of refined contour intervals, certain estimates may be somewhat inaccurate.

The largest site included here is the Maple Creek site which is probably the least likely to be constructed as it would flood considerable farmland without producing significant downstream benefits.

The Green Lake and Lake Terrell sites would provide for effective lake control and additional storage with subsequent downstream summer use of the water in areas deficient of irrigation water.

The Saar Creek reservoir could provide some relief from flash floods on the flat valley below as well as permitting an increase in the summer flow, and thereby making additional water available for appropriation.

The Anderson Creek, Deer Creek, Kelly Road, Markworth Road, Tenmile Creek, and the Upper Bertrand sites would all store winter and spring runoff for later summer consumption. Some of these sites may also offer recreational or lakefront possibilities.

The Barrett Lake, California Creek, and Dakota Creek sites would all entail channel storage almost exclusively but such reservoirs would greatly enhance the value of associated lakefront property. This water could also be utilized for irrigation, but because of their locations only adjacent farms would benefit.

Undoubtedly additional sites exist but are not included in this report as this is but a brief resume' of the smaller sites that have come to the attention of the authors.

DIVERSIONS

In addition to the major reservoir and storage sites, there are also numerous diversion locations in the basin. The majority of these would be for power diversions and are presently undeveloped as they require storage water to achieve effective utilization. All the diversion sites discussed are shown on plate 8.

EXISTING POWER DIVERSIONS

The only major power plant presently existing within the basin is the Puget Sound Power and Light Company's Excelsior plant directly below Nooksack Falls on the North Fork of the Nooksack River. The diversion dam itself is located directly above the falls. Constructed in 1906, the dam is about 10 feet high and 72 feet long. The Puget Sound Power and Light Company claims 328 cubic feet per second at the site, utilizing an elevation drop of 228 feet for a theoretical horsepower development of 8,953. However, the rated capacity of the installed waterwheels is 3,200 horsepower and the generators 1,875 horsepower, with a useable head of about 210 feet. Thus, in actual practice probably not more than 125 cubic feet per second is effectively utilized for the production of power.

A smaller power diversion was made on Lower Bagley Lake by the Mt. Baker Lodge during the 1930's. This power project has since been abandoned due to weather difficulties, but the diversion dam still exists and raises the lake level about 8 feet.

UNDEVELOPED POWER DIVERSION SITES

R. O. Helland's report, "Water Utilization in the Nooksack River," 1941 and revised in 1954, discusses seven areas for power diversion development in the basin and was the major reference for the potential power diversion discussion. These seven sites are all similar in that they have no storage themselves, but rather rely on diversion structures to intercept the flow of one or more streams and transport this water in a canal or flume until sufficient volume and head is available for power development. The construction of either the Shuksan or North Fork dams would enhance the available power from diversions on the North Fork by making a much higher base flow available, and thus the reservoir project is an integral part of any diversion development in the basin. Only six of the seven sites discussed by Helland are mentioned here and shown on the Reservoir Map as the city of Bellingham's Middle Fork diversion has now made the seventh site unfeasible. No geologic or structural engineering studies have been made to determine the feasibility for such diversion dam construction.

The estimated power potentialities of these developments are all listed in table 32 on pages 102 and 103.

Swamp Creek Power Site.

The Swamp Creek power site would utilize the flow of Swamp and Ruth Creeks, diverting both at about 3,020 foot level. The powerhouse would be located just above the Shuksan Dam reservoir near the mouth of Swamp Creek.

Glacier Power Site.

This site would be located in the SE¼NW¼ of Sec. 6, Twp. 39 N., Rge. 7 E.W.M. The water would be obtained from the Lower Excelsior diversion on the North Fork at elevation 1,800 feet and the diversion canal would also pick up the flow of Deer Horn, Lookout, and Coal Creeks while providing an effective head of 920 feet. The Canyon Creek flow could also be diverted in Sec. 19, Twp. 40 N., Rge. 7 E.W.M., and carried by canal to the same forebay, thus contributing to the available power at the Glacier power site. The amount of power available from this site would be dependent upon the development of storage facilities at either the North Fork or Shuksan reservoir sites.

Warnick Power Site.

The North Fork could again be diverted at the Upper Warnick diversion in the SE¼NW¼ of Sec. 1, Twp. 39 N., Rge. 6 E.W.M., at elevation 773 feet, using a 47 foot high dam to back water up to the Glacier powerhouse. Just above the tailwaters of the Maple Falls reservoir, 3.5 miles of canal would carry the water to the powerhouse in the NW¼SE¼ of Sec. 29, Twp. 40 N., Rge. 6 E.W.M., at elevation 600 feet. This would provide an effective head of about 160 feet, but like the Glacier powerhouse, would be extremely dependent upon a Shuksan or North Fork reservoir for most effective development.

Glacier Creek Power Site.

This power development would require the diversion of Glacier Creek at elevation 2,500 feet in the SW¼SW¼ of Sec. 34, Twp. 39 N., Rge. 7 E.W.M., and carry water to the center of Sec. 17, gaining the flows of Falls, Coal, and Deep Creeks on the way. Diversions on Little and Davis Creeks would also contribute substantially to the flow. Also, Gallup, Cornell, and West Cornell Creeks should be considered as contributors to this project even though they are not shown on the map. Consideration should also be given to utilizing the Glacier powerhouse, thus avoiding the necessity of constructing an additional powerhouse.

Clearwater Creek Power Site.

This is the only remaining power site on the Middle Fork of the Nooksack River since Bellingham's proposed diversion of up to 250 cubic feet per second in Sec. 19, Twp.38 N., Rge. 6 E.W.M., will make others impossible. The Clearwater site would utilize the Middle Fork through the Upper Middle Fork diversion just below the mouth of Green Creek at elevation 2,000 feet. This flow would be carried to a point in Sec. 21, Twp. 38 N., Rge. 6 E.W.M., gaining the flows of Wallace and Warm Creeks enroute, and discharging through a powerhouse at elevation 1,180 feet just above the mouth of Clearwater Creek. Clearwater Creek itself would be diverted at about the 2,000 foot level, just below Rocky Creek in Sec. 2, Twp. 38 N., Rge. 6 E.W.M., and its flow carried to the same penstock. This would provide development of water from a 44 square mile drainage area.

Wanlick Creek Power Site.

The diversion of the South Fork of the Nooksack River just below the mouth of Wanlick Creek at elevation 1,820 feet would provide considerable seasonal power by carrying the water to a powerhouse in Sec. 22, Twp. 36 N., Rge. 6 E.W.M., at the tailwaters of the Edfro or Skookum Creek reservoirs on the South Fork. The flow of Howard Creek could also be gained on the way. There is no feasible storage here, so any power obtained would be dependent upon natural flow.

MISCELLANEOUS DIVERSIONS

City of Bellingham.

This diversion of the Middle Fork is located in Sec. 19, Twp. 38 N., Rge. 6 E.W. M., and is by far the largest single consumptive diversion in the basin. An 18-foot diversion structure is presently under construction to divert water into Mirror Lake by pipe and canal and thence into Lake Whatcom.

F. Baker.

The F. Baker diversion is a private project on Lummi Island that prevents water from flowing directly down a cliff and into Puget Sound by diverting it in the opposite direction toward the north part of the island where it is used for irrigation, emergency power production, and domestic supply. Additional water is available here and more complete development and use of this water is being contemplated.